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ABSTRACT

This Unified Sciences and Mathematics for Elementary Schools (USMES) unit challenges students to change their classroom to make it a better place to live and study. The challenge is general enough to apply to many problem-solving situations in mathematics, science, social science, and language arts at any elementary school level (grades 1-8). The Teacher Resource Book for the unit is divided into five sections. Section I describes the USMES approach to student-initiated investigations of real problems, including a discussion of the nature of USMES "challenges." Section II provides an overview of possible student activities with comments on prerequisite skills, instructional strategies, suggestions when using the unit with primary grades, flow charts illustrating how investigations evolve from students' discussions of classroom design problems (focusing on decorations, furniture arrangement/design, sound, heating, lighting), and a hypothetical account of intermediate-level class activities. Section III provides documented events of actual class activities from grades 1, 5, and 6. Section IV includes lists of "How To" cards and background papers, bibliography of non-USMES materials, and a glossary. Section V consists of charts identifying skills, concepts, processes, and areas of study learned as students become involved with classroom design investigations. (JN)

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UNIFIED SCIENCES AND MATHEMATICS FOR ELEMENTARY SCHOOLS:
Mathematics and the Natural, Social, and Communications Sciences in
Real Problem Solving.

Classroom Design

Second Edition

Education Development Center, Inc.
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Trial Edition

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CHALLENGE: CHANGE THE CLASSROOM TO MAKE IT A BETTER PLACE

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Preface

The USMES Project

Unified Sciences and Mathematics for Elementary Schools: Mathematics and the Natural, Social, and Communications Sciences in Real Problem Solving (USMES) was formed in response to the recommendations of the 1967 Cambridge Conference on the Correlation of Science and Mathematics in the Schools.* Since its inception in 1970, USMES has been funded by the National Science Foundation to develop and carry out field trials of interdisciplinary units centered on long-range investigations of real and practical problems (or "challenges") taken from the local school/community environment. School planners can use these units to design a flexible curriculum for grades one through eight in which real problem solving plays an important role.

Development and field trials were carried out by teachers and students in the classroom with the assistance of university specialists at workshops and at occasional other meetings. The work was coordinated by a staff at the Education Development Center in Newton, Massachusetts. In addition, the staff at EDC coordinated implementation programs involving schools, districts, and colleges that are carrying out local USMES implementation programs for teachers and schools in their area.

Trial editions of the following units are currently available:

Advertising
Bicycle Transportation
Classroom Design
Classroom Management
Consumer Research
Describing People
Designing for Human Proportions
#Design Lab Design
#Eating in School
Getting There
Growing Plants
Manufacturing
Mass Communications
Nature Trails
Orientation
Pedestrian Crossings
Play Area Design and Use
Protecting Property
#School Rules
School Supplies
School Zoo
Soft Drink Design
Traffic Flow
#Using Free Time
Ways to Learn/Teach
Weather Predictions

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*See *Goals for the Correlation of Elementary Science and Mathematics*, Houghton Mifflin Co., Boston, 1969.

#Available fall 1976.

USMES Resources

In responding to a long-range challenge, the students and teachers often have need of a wide range of resources. In fact, all of the people and materials in the school and community are important resources for USMES activities. USMES provides resources in addition to these. One resource for students is the Design Lab or its classroom equivalent: using the tools and supplies available, children can follow through on their ideas by constructing measuring tools, testing apparatus, models, etc. Another resource for students is the *"How To" Cards*. Each set of cards gives information about a specific problem; the students use a set only when they want help on that particular problem.

Several types of resources are available for teachers: the *USMES Guide*, a *Teacher Resource Book* for each challenge, *Background Papers*, a *Design Lab Manual*, and a *Curriculum Correlation Guide*. A complete set of all these written materials comprise what is called the USMES library. This library, which should be available in each school using USMES units, contains the following:

1. *The USMES Guide*

   The USMES Guide is a compilation of materials that may be used for long-range planning of a curriculum that incorporates the USMES program. In addition to basic information about the project, the challenges, and related materials, it contains charts assessing the strengths of the various challenges in terms of their possible subject area content.

2. *Teacher Resource Books* (one for each challenge)

   Each book contains a description of the USMES approach to real problem-solving activities, general information about the particular unit, edited logs of class activities, other written materials relevant to the unit, and charts that indicate the basic skills, processes, and areas of study that may be learned and utilized as students become engaged in certain possible activities.

3. *Design Lab Manual*

   This contains sections on the style of Design Lab activities, safety considerations, and an inventory of tools and supplies. Because many "hands-on" activities may take place in the classroom, the Design Lab Manual should be made available to each USMES teacher.

4. *"How To" Cards*

   These short sets of cards provide information to students about specific problems that may arise during USMES units. Particular computation, graphing, and construction problems are discussed. A complete list of the "How To" Cards can be found in the USMES Guide.

5. *Background Papers*

   These papers are written to provide information for the teachers on technical problems that might arise as students carry on various investigations. A complete list of the Background Papers can be found in the USMES Guide.

6. *Curriculum Correlation Guide*

   This volume is intended to coordinate other curriculum materials with the Teacher Resource Books and to provide the teacher with the means to integrate USMES easily into other school activities and lessons.

The preceding materials are described in brief in the USMES brochure, which can be used by teachers and administrators to disseminate information about the program to the local community. A variety of other dissemination and implementation materials are also available for individuals and groups involved in local implementation programs. They include *Preparing People for USMES: An Implementation Resource Book*, the USMES slide/tape show, the Design Lab slide/tape show, the Design Lab brochure, the USMES newsletter, videotapes of classroom activities, a general report on evaluation results, a map showing the locations of schools conducting local implementation of USMES, a list of experienced USMES teachers and university consultants, and newspaper and magazine articles.

Acknowledgments

Besides the contributors listed at the beginning of the book, we are deeply indebted to the many elementary school children whose investigations of the challenge form the basis for this book. Without their efforts this book would not have been possible. Many thanks to the Planning Committee for their years of service and advice. Many thanks also to other members of the USMES staff for their suggestions and advice and for their help in staffing and organizing the development workshops. Special thanks also go to Christopher Hale for his efforts as Project Manager during the development of this book.

* * *

Because Tri-Wall was the only readily available brand of three-layered cardboard at the time the project began, USMES has used it at workshops and in schools; consequently, references to Tri-Wall can be found throughout the Teacher Resource Books. The addresses of companies that supply three-layered cardboard can be found in the Design Lab Manual.

Introduction

Using the Teacher Resource Book

When teachers try a new curriculum for the first time, they need to understand the philosophy behind the curriculum. The USMES approach to student-initiated investigations of real problems is outlined in section A of this Teacher Resource Book.

Section B starts with a brief overview of possible student activities arising from the challenge; comments on prerequisite skills are included. Following that is a discussion of the classroom strategy for USMES real problem-solving activities, including introduction of the challenge, student activity, resources, and Design Lab use. Subsequent pages include a description of the use of the unit in primary grades, a flow chart and a composite log that indicate the range of possible student work, and a list of questions that the teacher may find useful for focusing the students' activities on the challenge.

Because students initiate all the activities in response to the challenge and because the work of one class may differ from that undertaken by other classes, teachers familiar with USMES need to read only sections A and B before introducing the challenge to students.

Section C of this book is the documentation section. These edited teachers' logs show the variety of ways in which students in different classes have worked at finding a solution to the challenge.

Section D contains a list of the titles of relevant sets of "How To" Cards and brief descriptions of the Background Papers pertaining to the unit. Also included in section D is a glossary of the terms used in the Teacher Resource Book and an annotated bibliography.

Section E contains charts that indicate the comparative strengths of the unit in terms of real problem solving, mathematics, science, social science, and language arts. It also contains a list of explicit examples of real problem solving and other subject area skills, processes, and areas of study learned and utilized in the unit. These charts and lists are based on documentation of activities that have taken place in USMES classes. Knowing ahead of time which basic skills and processes are likely to be utilized, teachers can postpone teaching that part of their regular program until later in the year. At that time students can study them in the usual way if they have not already learned them as part of their USMES activities.

A. Real Problem Solving and USMES

> *If life were of such a constant nature that there were only a few chores to do and they were done over and over in exactly the same way, the case for knowing how to solve problems would not be so compelling. All one would have to do would be to learn how to do the few jobs at the outset. From then on he could rely on memory and habit. Fortunately--or unfortunately depending upon one's point of view--life is not simple and unchanging. Rather it is changing so rapidly that about all we can predict is that things will be different in the future. In such a world the ability to adjust and to solve one's problems is of paramount importance.**

Real Problem Solving

USMES is based on the beliefs that real problem solving is an important skill to be learned and that many math, science, social science, and language arts skills may be learned more quickly and easily within the context of student investigations of real problems. Real problem solving, as exemplified by USMES, implies a style of education which involves students in investigating and solving real problems. It provides the bridge between the abstractions of the school curriculum and the world of the student. Each USMES unit presents a problem in the form of a challenge that is interesting to children because it is both real and practical. The problem is real in several respects: (1) the problem applies to some aspect of student life in the school or community, (2) a solution is needed and not presently known, at least for the particular case in question, (3) the students must consider the entire situation with all the accompanying variables and complexities, and (4) the problem is such that the work done by the students can lead to some improvement in the situation. This expectation of useful accomplishment provides the motivation for children to carry out the comprehensive investigations needed to find some solution to the challenge.

The level at which the children approach the problems, the investigations that they carry out, and the solutions that they devise may vary according to the age and ability of the children. However, real problem solving involves them, at some level, in all aspects of the problem-solving process: definition of the problem; determination of the important factors in the problem; observation; measurement; collection of data; analysis of the data using graphs, charts, statistics, or whatever means the students can find; discussion; formulation and trial of suggested solutions; clarification of values; decision making; and communications of findings to others. In addition, students become more inquisitive, more cooperative in working with others, more critical in their thinking, more self-reliant, and more interested in helping to improve social conditions.

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*Kenneth B. Henderson and Robert E. Pingry, "Problem-Solving in Mathematics," in *The Learning of Mathematics: Its Theory and Practice*, Twenty-first Yearbook of the National Council of Teachers of Mathematics (Washington, D.C.: The Council, 1953), p. 233.

The USMES Approach

To learn the process of real problem solving, the students must encounter, formulate, and find some solution to complete and realistic problems. The students themselves, not the teacher, must analyze the problem, choose the variables that should be investigated, search out the facts, and judge the correctness of their hypotheses and conclusions. In real problem-solving activities, the teacher acts as a coordinator and collaborator, not an authoritative answer-giver.

The problem is first reworded by students in specific terms that apply to their school or community, and the various aspects of the problem are discussed by the class. The students then suggest approaches to the problem and set priorities for the investigations they plan to carry out. A typical USMES class consists of several groups working on different aspects of the problem. As the groups report periodically to the class on their progress, new directions are identified and new task forces are formed as needed. Thus, work on an USMES challenge provides students with a "discovery-learning" or "action-oriented" experience.

Real problem solving does not rely solely on the discovery-learning concept. In the real world people have access to certain facts and techniques when they recognize the need for them. The same should be true in the classroom. When the students find that certain facts and skills are necessary for continuing their investigation, they learn willingly and quickly in a more directed way to acquire these facts and skills. Consequently, the students should have available different resources that they may use as they recognize the need for them, but they should still be left with a wide scope to explore their own ideas and methods.

Certain information on specific skills is provided by the sets of USMES "How To" Cards. The students are referred only to the set for which they have clearly identified a need and only when they are unable to proceed on their own. Each "How To" Cards title clearly indicates the skill involved--"How to Use a Stopwatch," "How to Make a Bar Graph Picture of Your Data," etc. (A complete list of the "How To" Cards can be found in Chapter IX of the USMES Guide.)

Another resource provided by USMES is the Design Lab or its classroom equivalent. The Design Lab provides a central location for tools and materials where devices may be constructed and tested without appreciably disrupting other classroom activities. Ideally, it is a separate room with space for all necessary supplies and equipment and work space for the children. However, it may be as small as a corner of the classroom and may contain only a few tools and supplies. Since the benefits of real problem solving can be obtained by the students only if they have a means to follow up their ideas, the availability of a Design Lab can be a very important asset.

Optimally, the operation of the school's Design Lab should be such as to make it available to the students whenever they need it. It should be as free as possible from set scheduling or programming. The students use the Design Lab to try out their own ideas and/or to design, construct, test, and improve many devices initiated by their responses to the USMES challenges. While this optimum operation of the Design Lab may not always be possible due to various limitations, "hands-on" activities may take place in the classroom even though a Design Lab may not be available. (A detailed discussion of the Design Lab can be found in Chapter VI of the USMES Guide, while a complete list of "How To" Cards covering such Design Lab skills as sawing, gluing, nailing, soldering, is contained in Chapter IX.)

Work on all USMES challenges is not only sufficiently complex to require the collaboration of the whole class but also diverse enough to enable each student to contribute according to his/her interest and ability. However, it should be noted that if fewer than ten to twelve students from the class are carrying out the investigation of a unit challenge, the extent of their discovery and learning can be expected to be less than if more members of the class are involved. While it is possible for a class to work on two related units at the same time, in many classes the students progress better with just one.

The amount of time spent each week working on an USMES challenge is crucial to a successful resolution of the problem. Each challenge is designed so that the various investigations will take from thirty to forty-five hours, depending on the age of the children, before some solution to the problem is found and some action is taken on the results of the investigations. Unless sessions are held at least two or three times a week, it is difficult for the children to maintain their interest and momentum and to become involved intensively with the challenge. The length of each session depends upon the age level of the children and the nature of the challenge. For example, children in the primary grades may proceed better by working on the challenge more frequently for shorter periods of time, perhaps fifteen to twenty minutes, while older children may proceed better by working less frequently for much longer periods of time.

Student interest and the overall accomplishments of the class in finding and implementing solutions to the challenge indicate when the class's general participation in unit activities should end. (Premature discontinuance of work on a specific challenge is often due more to waning interest on the part of the teacher than to that of the students.) However, some students may continue work on a voluntary basis on one problem, while the others begin to identify possible approaches to another USMES challenge.

Importance of the Challenge

Although individual (or group) discovery and student initiation of investigations is the process in USMES units, this does not imply the constant encouragement of random activity. Random activity has an important place in children's learning, and opportunities for it should be made available at various times. During USMES activities, however, it is believed that children learn to solve real problems only when their efforts are focused on finding some solution to the real and practical problem presented in the USMES challenge. It has been found that students are motivated to overcome many difficulties and frustrations in their efforts to achieve the goal of effecting some change or at least of providing some useful information to others. Because the children's commitment to finding a solution to the challenge is one of the keys to successful USMES work, it is extremely important that the challenge be introduced so that it is accepted by the class as an important problem to which they are willing to devote a considerable amount of time.

The challenge not only motivates the children by stating the problem but also provides them with a criterion for judging their results. This criterion--if it works, it's right (or if it helps us find an answer to our problem, it's a good thing to do)--gives the children's ideas and results a meaning within the context of their goal. Many teachers have found this concept to be a valuable strategy that not only allows the teacher to respond positively to all of the children's ideas but also helps the children themselves to judge the value of their efforts.

Role of the Teacher

With all of the above in mind, it can be said that the teacher's responsibility in the USMES strategy for open classroom activities is as follows:

1. Introduce the challenge in a meaningful way that not only allows the children to relate it to their particular situation but also opens up various avenues of approach.

2. Act as a coordinator and collaborator. Assist, not direct, individuals or groups of students as they investigate different aspects of the problem.

3. Hold USMES sessions at least two or three times a week so that the children have a chance to become involved in the challenge and carry out comprehensive investigations.

4. Provide the tools and supplies necessary for initial hands-on work in the classroom or make arrangements for the children to work in the Design Lab.

5. Be patient in letting the children make their own mistakes and find their own way. Offer assistance or point out sources of help for specific information (such as the "How To" Cards) only when the children become frustrated in their approach to the problem. Conduct skill sessions as necessary.

6. Provide frequent opportunities for group reports and student exchanges of ideas in class discussions. In most cases, students will, by their own critical examination of the procedures they have used, improve or set new directions in their investigations.

7. If necessary, ask appropriate questions to stimulate the students' thinking so that they will make more extensive and comprehensive investigations or analyses of their data.

8. Make sure that a sufficient number of students (usually ten to twelve) are working on the challenge so that activities do not become fragmented or stall.

Student success in USMES unit activities is indicated by the progress they make in finding some solution to the challenge, not by following a particular line of investigation nor by obtaining specified results. The teacher's role in the USMES strategy is to provide a classroom atmosphere in which all students can, in their own way, search out some solution to the challenge.

USMES in the Total School Program

Today many leading educators feel that real problem solving (under different names) is an important skill to be learned. In this mode of learning particular emphasis is placed on developing skills to deal with real problems rather than the skills needed to obtain "correct" answers to contrived problems. Because of this and because of the interdisciplinary nature of both the problems and the resultant investigations, USMES is ideal for use as an important part of the elementary school program. Much of the time normally spent in the class on the traditional approaches to math, science, social science, and language arts skills can be safely assigned to USMES activities. In fact, as much as one-fourth to one-third of the total school program might be allotted to work on USMES challenges. Teachers who have worked with USMES for several years have each succeeding year successfully assigned to USMES activities the learning of a greater number of traditional skills. In addition, reports have indicated that students retain for a long time the skills and concepts learned and practiced during USMES activities. Therefore, the time normally spent in reinforcing required skills can be greatly reduced if these skills are learned and practiced in the context of real problem solving.

Because real problem-solving activities cannot possibly cover all the skills and concepts in the major subject areas, other curricula as well as other learning modes (such as "lecture method," "individual study topics," or programmed instruction) need to be used in conjunction with USMES in an optimal education program. However, the other instruction will be enhanced by the skills, motivation, and understanding provided by real problem solving, and, in some cases, work on an USMES challenge provides the context within which the skills and concepts of the major subject areas find application.

In order for real problem solving taught by USMES to have an optimal value in the school program, class time should be apportioned with reason and forethought, and the sequence of challenges investigated by students during their years in elementary school should involve them in a variety of skills and processes. Because all activities are initiated by students in response to the challenge, it is impossible to state unequivocally which activities will take place. However, it is possible to use the documentation of activities that have taken place in USMES trial classes to schedule instruction on the specific skills and processes required by the school system. Teachers can postpone the traditional way of teaching the skills that might come up in work on an USMES challenge until later in the year. At that time students can learn the required skills in the usual way if they have not already learned them during their USMES activities.

These basic skills, processes, and areas of study are listed in charts and lists contained in each Teacher Resource Book. A teacher can use these charts to decide on an overall allocation of class time between USMES and traditional learning in the major subject disciplines. Examples of individual skills and processes are also given so that the teacher can see beforehand which skills a student may encounter during the course of his investigations. These charts and lists may be found in section E.

Ways In Which USMES Differs From Other Curricula

As the foregoing indicates, USMES differs significantly from other curricula. Real problem solving develops the problem-solving ability of students and does it in a way (learning-by-doing) that leads to a full understanding of the process. Because of the following differences, some teacher preparation is necessary. Some teachers may have been introduced by other projects to several of the following new developments in education, but few teachers have integrated all of them into the new style of teaching and learning that real problem solving involves.

1. New Area of Learning--Real problem solving is a new area of learning, not just a new approach or a new content within an already-defined subject area. Although many subject-matter curricula

include something called problem solving, much of this problem solving involves contrived problems or fragments of a whole situation and does not require the cognitive skills needed for the investigation of real and practical problems. Learning the cognitive strategy required for real problem solving is different from other kinds of learning.

3. Interdisciplinary Education--Real problem solving integrates the disciplines in a natural way; there is no need to impose a multi-disciplinary structure. Solving real and practical problems requires the application of skills, concepts, and processes from many disciplines. The number and range of disciplines are unrestricted and the importance of each is demonstrated in working toward the solution of practical problems.

3. Student Planning--To learn the process of problem solving, the students themselves, not the teacher, must analyze the problem, choose the variables that should be investigated, search out the facts, and judge the correctness of the hypotheses and conclusions. In real problem-solving activities the teacher acts as a coordinator and collaborator, not as an authoritative source of answers.

4. Learning-by-Doing--Learning-by-doing, or discovery learning as it is sometimes called, comes about naturally in real problem solving since the problems tackled by each class have unique aspects; for example, different lunchrooms or pedestrian crossings have different problems associated with them and, consequently, unique solutions. The challenge, as defined in each situation, provides the focus for the children's hands-on learning experiences, such as collecting real data; constructing measuring instruments, scale models, test equipment, etc.; trying their suggested improvements; and (in some units) preparing reports and presentations of their findings for the proper authorities.

5. Learning Skills and Concepts as Needed--Skills and concepts are learned in real problem solving

as the need for them arises in the context of the work being done, rather than having a situation imposed by the teacher or the textbook being used. Teachers may direct this learning when the need for it arises, or students may search out information themselves from resources provided.

6. Group Work--Progress toward a solution to a real problem usually requires the efforts of groups of students, not just individual students working alone. Although some work may be done individually, the total group effort provides good opportunities for division of labor and exchange of ideas among the groups and individuals. The grouping is flexible and changes in order to meet the needs of the different stages of investigation.

7. Student Choice--Real problem solving offers classes the opportunity to work on problems that are real to them, not just to the adults who prepare the curriculum. In addition, students may choose to investigate particular aspects of the problem according to their interest. The variety of activities ensuing from the challenge allows each student to make some contribution towards the solution of the problem according to his or her ability and to learn specific skills at a time when he or she is ready for that particular intellectual structure.

B. General Papers on Classroom Design

1. OVERVIEW OF ACTIVITIES

Challenge:

Change the classroom to make it a better place.

Possible Class Challenges:

Make the classroom a better place for learning.

Find ways to make the classroom more suitable for those who use it.

Children are usually very eager to improve their classroom and can readily identify aspects of their room that could stand a change. The room may be too hot or too cool; it may be too bare and dull. Supplies may be disorganized. The students may not like their desks; they may prefer tables. Perhaps noise or inadequate lighting hinders their concentration. From a discussion of such complaints, the children and their teacher may formulate an appropriate class challenge.

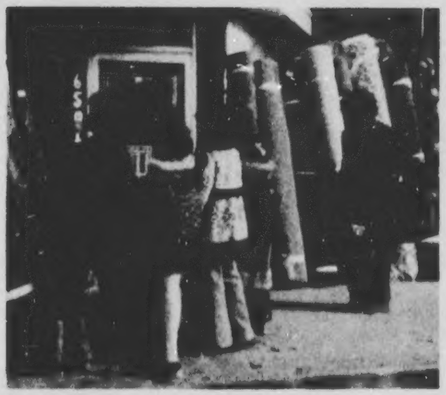
A long list of problems may emerge during the initial class session, in which case the children can establish priorities. Conducting a survey or simply voting can help the class determine which items are the most critical. The class may postpone work on some problems until the major improvements have taken place. Next, the children may generate from their major goal a list of specific objectives or a plan of action and then form groups accordingly.

Initial tasks usually involve data collection. Children concerned with decorating may survey classmates about color preferences or types of decorations. Or they may research availability and suitability of materials.

Data collection can take other forms as well. A class investigating lighting or sound problems may need to design and build appropriate measuring instruments. These children may also devise and conduct standardized tests to see how students perform under varying conditions. Such tests provide a base for later evaluating implemented changes.

A class focusing on furniture design and arrangement might observe other classrooms or look through catalogs for ideas. A seating-preference survey can help students decide on favorable sizes and shapes for tables. Some children may work on a Designing for Human Proportions challenge, measuring bodily dimensions such as height, foot-to-knee distance, and hip-to-shoulder span to ensure that any furniture constructed will fit those who use it. Students may measure the dimensions of the classroom and the furniture to build a scale layout of the room on which they can experiment with furniture arrangements.

Children may depict their data on graphs and analyze these during a class discussion. After interpreting the information, children can propose solutions to the problems



and talk about pros and cons of suggested room improvements. Some students may examine such items as fire regulations and costs and availability of materials.

Fund-raising events, planned and run by the students, may cover the cost of paint, a new rug, wood, or class games. A scrounging campaign might also produce the materials needed for constructing tables, shelves, study carrels, or lamps.

To measure their success, children might conduct an attitude survey of the class. Students who conducted tests of the performance of classmates under pre-improvement conditions, might run a series of posttests and then evaluate any differences. Children who altered lighting, sound, or temperature conditions, might remeasure to quantify the extent of any improvement. Even after agreeing that they have successfully met their challenge, children may occasionally make further improvements.

Although many of these activities may require skills and concepts new to the children, there is no need for preliminary work on these skills and concepts because the children can learn them when the need arises. In fact, children learn more quickly and easily when they see a need to learn. Consider counting: whereas children usually learn to count by rote, they can, through USMES, gain a better understanding of counting by learning or practicing it within real contexts. In working on Classroom Design children also learn and practice graphing, measuring, working with decimals, and dividing. Although dividing seems necessary to compare fractions or ratios, primary children can make comparisons graphically; sets of data can also be compared graphically or by subtracting medians (half-way values). Furthermore, instead of using division to make scale drawings, younger children can convert their measurements to spaces on graph paper. Division may be introduced at the proper grade level during calculation of percentages, averages, or unit costs.

2. CLASSROOM STRATEGY FOR CLASSROOM DESIGN

Each USMES unit revolves around a challenge--a statement that says, "Solve this problem." The success or failure of the unit depends largely on (1) the relevance of the problem for the students and (2) the process by which they define and accept the challenge. If the children see the problem as a real one, they will be committed to finding a solution; they will have a focus and purpose for their activities.

If the students do not think the problem affects them, their attempts at finding solutions will likely be disjointed and cursory.

The Classroom Design challenge, "Change the classroom to make it a better place," is general enough to apply to many situations. Students in different classes define and reword the challenge to fit the particular problems of their classrooms and thus arrive at a specific class challenge. "Create a study area in the classroom" might be the challenge for a class in which the children feel they need a place for quiet work.

The Process of Introducing the Challenge

Given that a problem exists, how can a teacher, without being directive, help the students identify the challenge that they will work on as a group? There is no set method because of variations among teachers, classes, and schools and among the USMES units themselves. However, USMES teachers have found that certain general techniques in introducing the challenge are helpful.

One such technique is to turn a discussion of some recent event toward a Classroom Design challenge. For example, during a discussion of a heat wave, the teacher might ask the children whether the unusually high temperatures have affected their work in class. Similarly, a recent fire drill may precipitate a discussion about whether the furniture arrangement in the room affords a safe and speedy exit.

A Classroom Design challenge may arise from the children's work on a different USMES unit. Students who have set up an in-class lab in response to a Design Lab Design challenge may decide to further modify their classroom and make it serve them better. When children working on one challenge encounter a problem that leads to a related Classroom Design challenge, one group of children may begin work on this second challenge while the rest of the class continues with the first challenge. However, there should be at least ten to twelve students working on any one challenge; otherwise, the children's work may be fragmented or superficial or break down completely.

A Classroom Design challenge may also evolve from a discussion of a specific topic being studied by the class. A class studying a science topic, such as heat or light, may become interested in improving physical conditions in the classroom.

Sometimes the discussion of a broad problem may encompass the challenges of several related units. For example, a discussion of problems at school could lead to Classroom Design, Classroom Management, Eating in School, Orientation, Play Area Design and Use, or School Supplies, depending on which specific problems the children identify.

An experienced USMES teacher is usually willing to have the children work on any one of the several challenges that may arise during the discussion of a broad problem. While this approach gives the children the opportunity to select the challenge they are most interested in investigating, it does place on the teacher the additional responsibility of being prepared to act as a resource person for whichever challenge is chosen.

Classroom experience has shown that children's progress on a Classroom Design challenge may be poor if the teacher and students do not reach a common understanding of what the challenge is before beginning work on it. Having no shared focus for their work, the children will lack the motivation inherent in working together to solve a real problem. As a result, they may quickly lose interest.

A similar situation occurs if the teacher, rather than ensuring that the children have agreed upon a challenge, merely assigns a series of activities. Although the teacher may see how these activities relate to an overall goal, the children may not.

An intermediate-grade teacher scheduled Classroom Design activities for her class. Although class discussions focused on improving the classroom, there is no record of a challenge ever being issued. Students' attention, during the time allotted for USMES, focused on selecting classroom officers, rearranging desks and improving class discussion. But the children were unable to get involved in their investigations and see them to completion; interest waned and attempts to improve the classroom were fragmented.

Initial Work on the Challenge

Once a class has decided to work on a Classroom Design challenge, USMES sessions should be held several times a week, but they need not be rigidly scheduled. When sessions are held after long intervals, students often have difficulty remembering exactly where they were in their investigations, and momentum diminishes.

During the initial session, children list classroom problems; and the list usually is long. By lumping together similar complaints and by choosing one or two major problems to work on first, the class can arrive at a manageable challenge. If the students try to tackle too many problems at once, their investigations will be superficial.

> *A fifth-grade teacher issued the Classroom Design challenge during a discussion about how the children viewed the classroom. The class compiled a large list of areas in need of improvement: furniture arrangement, furniture design, classroom management, room decorations, and heating. Children formed groups and began their investigations. The diversity of topics resulted in fragmented activities and superficial investigations. The teacher's early diagnosis of the problem enabled him to help the children confine their efforts to two areas: heating and furniture design. Later in the term, other problems were tackled. Once the teacher and the class limited the directions taken at any given time, more in-depth investigations were undertaken and the children's involvement increased.*

Once they have agreed upon which problem in the classroom deserves their immediate attention, the children suggest approaches to solving it. Next, they categorize their suggestions, list the tasks necessary to carry out their ideas, and set priorities for these tasks.

Students form groups to work on the tasks they have listed. However, if too many groups are formed, work on the challenge can become fragmented. The teacher finds it impossible to be aware of the progress and problems of each group; in addition, the small number of students in each group lessens the chance for varied input and interaction.

Refocusing on the Challenge

As children work on a Classroom Design challenge, their attention should, from time to time, be refocused on that challenge so that they do not lose sight of their overall goal. Refocusing is particularly important with younger children because they have a shorter attention span. Teachers find it helpful to hold periodic class discussions that include group reports. Such sessions help the students review what they have accomplished and what they still need to do in order to find some solutions to the problem. These discussions also provide an opportunity for students to participate both in evaluating their own work and in exchanging ideas with their classmates. (Another consequence of having too many groups is that not every group can be given enough time to report to the class, thereby increasing the possibility that the children's efforts will overlap unnecessarily.)

Resources for Work on the Challenge

When children try to decide on solutions before collecting and analyzing enough data or encounter difficulties during their investigations, an USMES teacher helps out. But instead of giving answers or suggesting specific procedures, the teacher asks open-ended questions that stimulate the students to think more comprehensively and creatively about their work. For example, instead of telling students that their measurements of room temperature were invalid because the thermometers were not standardized, the teacher might ask, "How can you make sure that your results are accurate?" or "What reasons can you think of for the inconsistent measurements?" Examples of other nondirective, thought-provoking questions are given in section B-6.

The teacher may also refer students to the "How To" Cards, which provide information about specific skills, such as using a stopwatch or drawing graphs. If many students, or even the entire class, need help in particular areas, such as using fractions, the teacher should conduct skill sessions as these needs arise. (Background Papers provide teachers with additional information on specific problems associated with the Classroom Design challenge and on general topics applicable to most challenges.)

USMES teachers can also assist students by making it possible for them to carry out tasks involving hands-on activities. If the children need to collect data in other classrooms, the teacher can help with scheduling and supervision. If the children's tasks require them to design and construct items, such as measuring instruments or classroom furniture, the teacher should make sure that the students have access to a Design Lab. Any collection of tools and materials kept in a central location (in part of the classroom, on a portable cart, or in a separate room) can be called a Design Lab.

Valuable as it is, a Design Lab is not necessary to begin work on a Classroom Design challenge. The Design Lab is used only when needed, and this need may not arise during early work on the Classroom Design challenge. To carry out construction activities in schools without Design Labs, students may scrounge or borrow tools and supplies from parents, local businesses, or other members of the community or raise funds to purchase materials.

A fifth-grade teacher in a school without a Design Lab introduced the Classroom Design challenge to her students. The children decided that a new furniture arrangement was their immediate goal. They became very involved in recording the original arrangement, measuring the room, drawing a plan to scale, and finally, rearranging the furniture. After these tasks were completed, the children refocused on the challenge and explored other ways to improve their classroom. The class planned and constructed study modules for the room. Materials were scrounged, and parents were asked to help complete the project.

Sixth graders in another school without a Design Lab worked on Classroom Design. All unit work had to be completed in the room. Groups were formed to improve the wall area, floor area, window area, and game area. Much measuring and surveying was done. To raise funds for materials, a Christmas sale for the school was planned and run by the class. Items paid for by the proceeds included a rug and indoor and outdoor games. In addition, children scrounged materials to build portable study carrels to be used during testing periods and when students wanted privacy.

The extent to which any Design Lab is used for Classroom Design varies with different classes because the children themselves determine the direction of the investigations and because the need for construction activities will depend upon which classroom problems are being tackled.

Culminating Activities

Student investigations generally continue until the children have agreed upon and implemented some solution to the problem. They may construct mailboxes, shelves, study carrels, or tables for the classroom; they may rearrange the furniture or revamp the decor; they might make a schedule for opening windows and doors, add reflective materials, or build acoustical barriers.

After the students have implemented their solution, they evaluate the effects of their changes by observing, by measuring, by conducting posttests or attitude surveys, or by having a class discussion. Children might observe whether the classroom seems quieter; they might measure temperature to see whether the room is cooler; they might devise and distribute a questionnaire to find out whether the class likes the new decor; or they might simply discuss whether they have met their challenge.

3. USE OF CLASSROOM DESIGN IN THE PRIMARY GRADES

Primary-grade children are just as good at complaining about their classroom as older students, and, like older children, they can make changes. Although first graders will not match the sophistication with which sixth graders conduct investigations, they can identify problems, propose solutions, collect and interpret data, and take effective action to meet their challenge.

In response to a question such as "What things don't you like about the classroom?" children in kindergarten through third grade may point out that supplies are disorganized, the room is drab, a reading area is needed, or the seating arrangement just isn't right. Any of these problems (and many others) can form the basis of a manageable Classroom Design challenge.

It is unlikely that primary children will choose a challenge that is over their heads. Even if they opt to work on a seemingly complex problem like lighting, heating, or noise, they need only solve the problem to their own satisfaction.

To decide which problems they should work on first, children usually vote. When the list of choices is long, each child can have two (or three) votes; this leads to a fairer decision. A ranking procedure may also make the final decision more acceptable; children give "ones" to their first choices, "twos" to their second choices, and so on. If there aren't too many items, the computations won't be too cumbersome.

Several groups may form to work on different aspects of the challenge. If the challenge is "Let's decorate our room to make it look nicer," one group may design, obtain materials for, and construct mobiles; another may try to acquire a rug for the room; a third may explore possibilities of painting or covering bare walls. Some teachers of primary classes prefer to have the whole class work together, at least at first. Others let the children form groups but allow only one group to work at a time.

Children may devise and conduct surveys to find out, for example, their classmates' preferences about rug color, seating plan, or size of a reading center. A trial survey conducted on a few class members may show the children that questions must be clear, concise, and carefully worded to yield the information that's needed.

Data from a survey may be tallied directly onto a bar graph simply by stacking blocks or making tally marks in appropriately labeled columns. Not only does this technique cut down on work, but it slims the chances that the data will overwhelm the children. The bar graph will help students interpret their results, and its preparation will have been a useful experience.

Children trying to improve furniture arrangement or seating plans may find that a model layout helps them visualize and test their ideas. Children who cannot divide can still make a scale drawing of their classroom by converting measurements to spaces on graph paper. Scale cutouts of tables and desks allow children to see different layouts without moving actual furniture.

If a primary class wants to calculate an average (e.g., the average of preferred heights for a wall decoration), the children can instead find the median, which is easier to find and often a better number to use than the average. They order their data from smallest to largest and count to find the middle number--no division is necessary.

Comparing ratios or percentages can also be done without dividing. Children planning to clean their desks, for example, and wanting the best deal on liquid cleaners can make a slope diagram* to represent the cost per ounce for different brands or sizes. The least steep line will indicate the cheapest buy.

Measuring the room (or part of it), if necessary, gives children the opportunity to use instruments like a trundle wheel, folding ruler, or tape measure. Students might even create their own units by counting paces or body lengths.

Even something as sophisticated as a three-dimensional graph is within the scope of primary-grade activities. For example, if students measure or judge light, temperature, or sound in different parts of the room, they can stack blocks on a scale drawing of the classroom. In such a graph, two dimensions indicate position in the room, the third (height) represents the level of what has been measured (light, temperature, or sound).

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*Formerly called triangle diagram.

Children in a primary class will not automatically work together toward one goal over a long period of time. Frequent class discussions in which groups report to one another help the students stay on track. During these sessions teachers often ask children how their work is helping them meet the challenge. Group reporting gives children a chance to help each other and provides an input to decision making and planning--"Now that we've heard what the different groups have done, where do we go from here?"

After children have made changes in the classroom, they may choose to find out how improved the situation actually is. Discussion, an attitude survey, posttests, or physical measurements may help them decide how effectively they have met their challenge and what they should do about it.

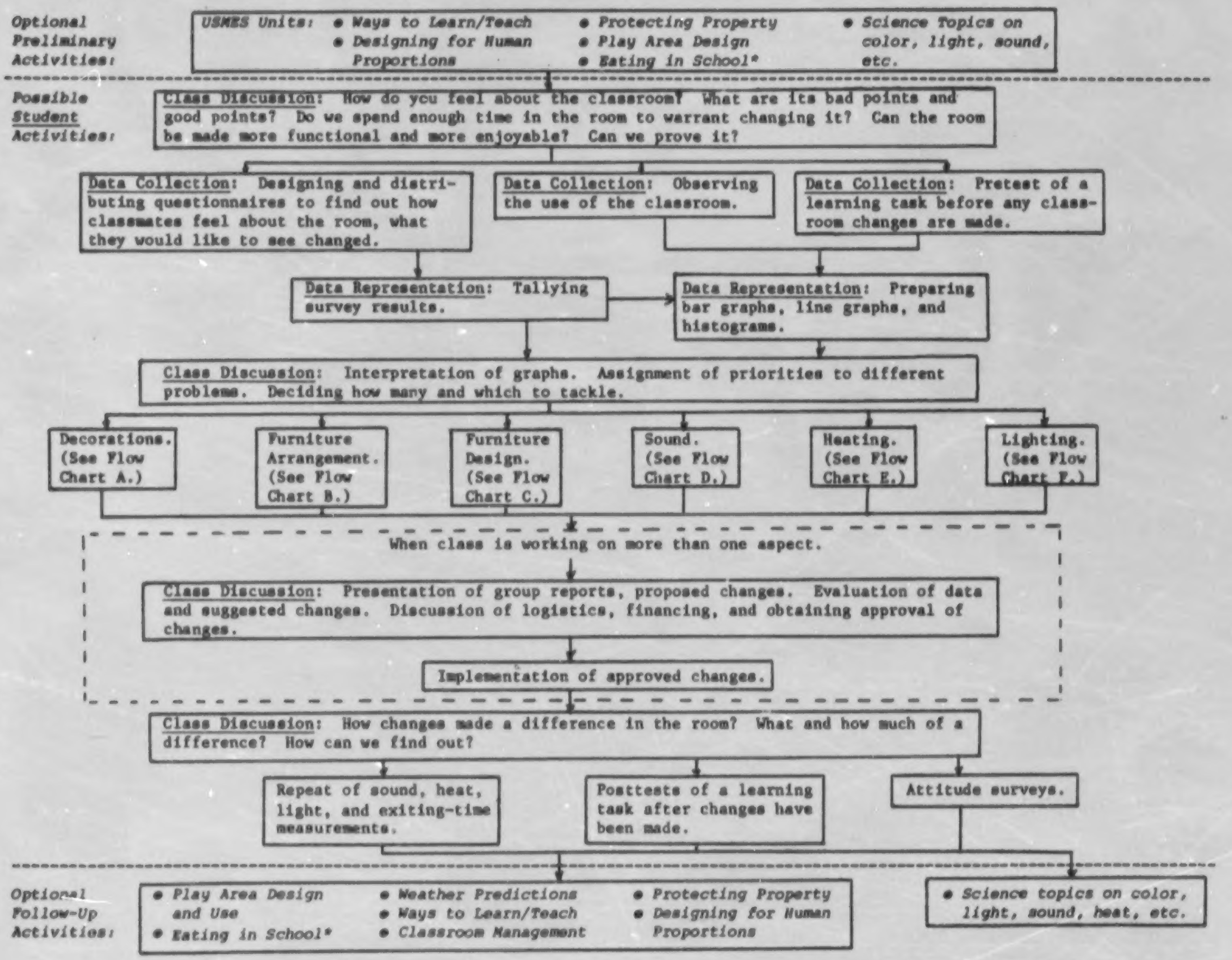
During the activities described here, children learn and practice, within a real context, skills and concepts in mathematics, language arts, science, and social science. But there's more. While working on Classroom Design, primary children improve their interpersonal relations, develop problem-solving abilities, and become confident that they are people who indeed can have a positive effect on the world in which they live.

4. FLOW CHART

The following flow charts present some of the student activities--discussions, observations, calculations, constructions--that may occur during work on the Classroom Design challenge. Because each class will choose its own approach to the challenge, the sequences of events given here represent only a few of the many possible variations. Furthermore, no one class is expected to undertake all the activities listed; a class usually works on just one of the aspects represented by the several charts.

The flow chart is not a lesson plan and should not be used as one. Instead, it illustrates how comprehensive investigations evolve from the students' discussion of a Classroom Design problem.

Challenge: Change the Classroom to make it a better place.



Optional Preliminary Activities:

USMES Units:
- *Ways to Learn/Teach*
- *Designing for Human Proportions*
- *Protecting Property*
- *Play Area Design*
- *Eating in School**
- *Science Topics on color, light, sound, etc.*

Possible Student Activities:

Class Discussion: How do you feel about the classroom? What are its bad points and good points? Do we spend enough time in the room to warrant changing it? Can the room be made more functional and more enjoyable? Can we prove it?

Data Collection: Designing and distributing questionnaires to find out how classmates feel about the room, what they would like to see changed.

Data Collection: Observing the use of the classroom.

Data Collection: Pretest of a learning task before any classroom changes are made.

Data Representation: Tallying survey results.

Data Representation: Preparing bar graphs, line graphs, and histograms.

Class Discussion: Interpretation of graphs. Assignment of priorities to different problems. Deciding how many and which to tackle.

Decorations. (See Flow Chart A.)

Furniture Arrangement. (See Flow Chart B.)

Furniture Design. (See Flow Chart C.)

Sound. (See Flow Chart D.)

Heating. (See Flow Chart E.)

Lighting. (See Flow Chart F.)

When class is working on more than one aspect.

Class Discussion: Presentation of group reports, proposed changes. Evaluation of data and suggested changes. Discussion of logistics, financing, and obtaining approval of changes.

Implementation of approved changes.

Class Discussion: How changes made a difference in the room? What and how much of a difference? How can we find out?

Repeat of sound, heat, light, and exiting-time measurements.

Posttests of a learning task after changes have been made.

Attitude surveys.

Optional Follow-Up Activities:

- *Play Area Design and Use*
- *Eating in School**
- *Weather Predictions*
- *Ways to Learn/Teach*
- *Classroom Management*
- *Protecting Property*
- *Designing for Human Proportions*

- *Science topics on color, light, sound, heat, etc.*

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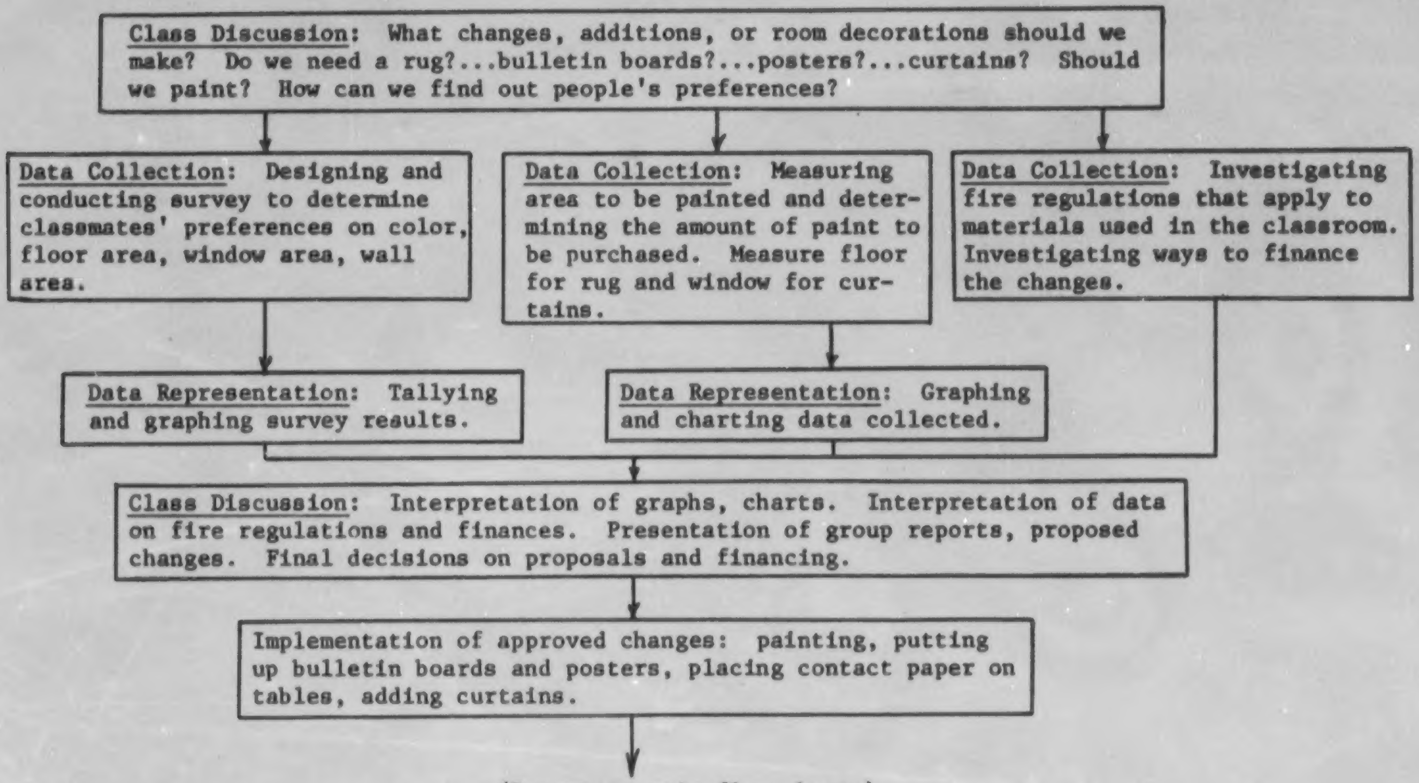
*Presently called Lunch Lines.

FLOW CHART A

Decorations



Class Discussion: What changes, additions, or room decorations should we make? Do we need a rug?...bulletin boards?...posters?...curtains? Should we paint? How can we find out people's preferences?

Data Collection: Designing and conducting survey to determine classmates' preferences on color, floor area, window area, wall area.

Data Collection: Measuring area to be painted and determining the amount of paint to be purchased. Measure floor for rug and window for curtains.

Data Collection: Investigating fire regulations that apply to materials used in the classroom. Investigating ways to finance the changes.

Data Representation: Tallying and graphing survey results.

Data Representation: Graphing and charting data collected.

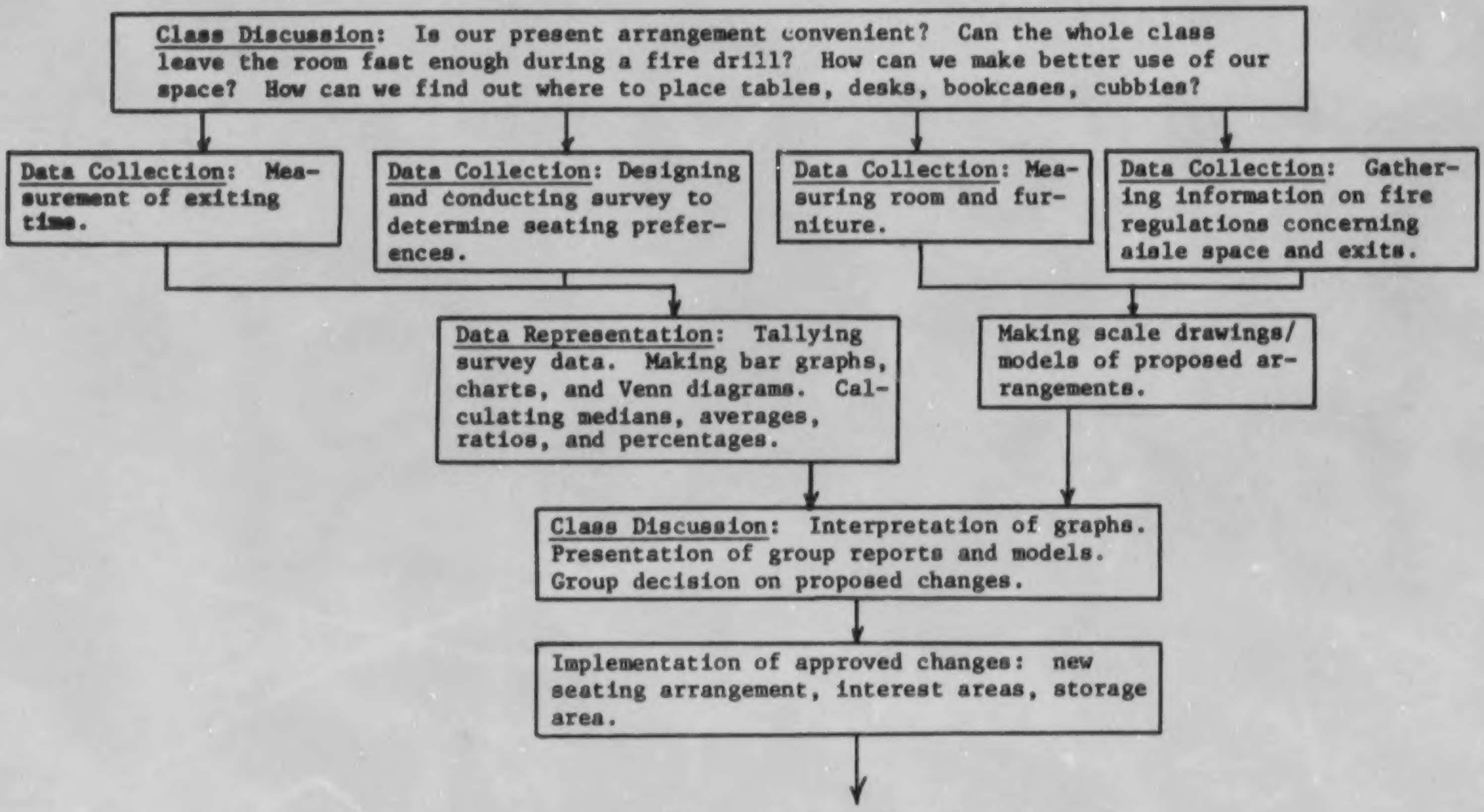
Class Discussion: Interpretation of graphs, charts. Interpretation of data on fire regulations and finances. Presentation of group reports, proposed changes. Final decisions on proposals and financing.

Implementation of approved changes: painting, putting up bulletin boards and posters, placing contact paper on tables, adding curtains.

(Return to main flow chart.)

FLOW CHART B

Furniture Arrangement



Class Discussion: Is our present arrangement convenient? Can the whole class leave the room fast enough during a fire drill? How can we make better use of our space? How can we find out where to place tables, desks, bookcases, cubbies?

Data Collection: Measurement of exiting time.

Data Collection: Designing and conducting survey to determine seating preferences.

Data Collection: Measuring room and furniture.

Data Collection: Gathering information on fire regulations concerning aisle space and exits.

Data Representation: Tallying survey data. Making bar graphs, charts, and Venn diagrams. Calculating medians, averages, ratios, and percentages.

Making scale drawings/models of proposed arrangements.

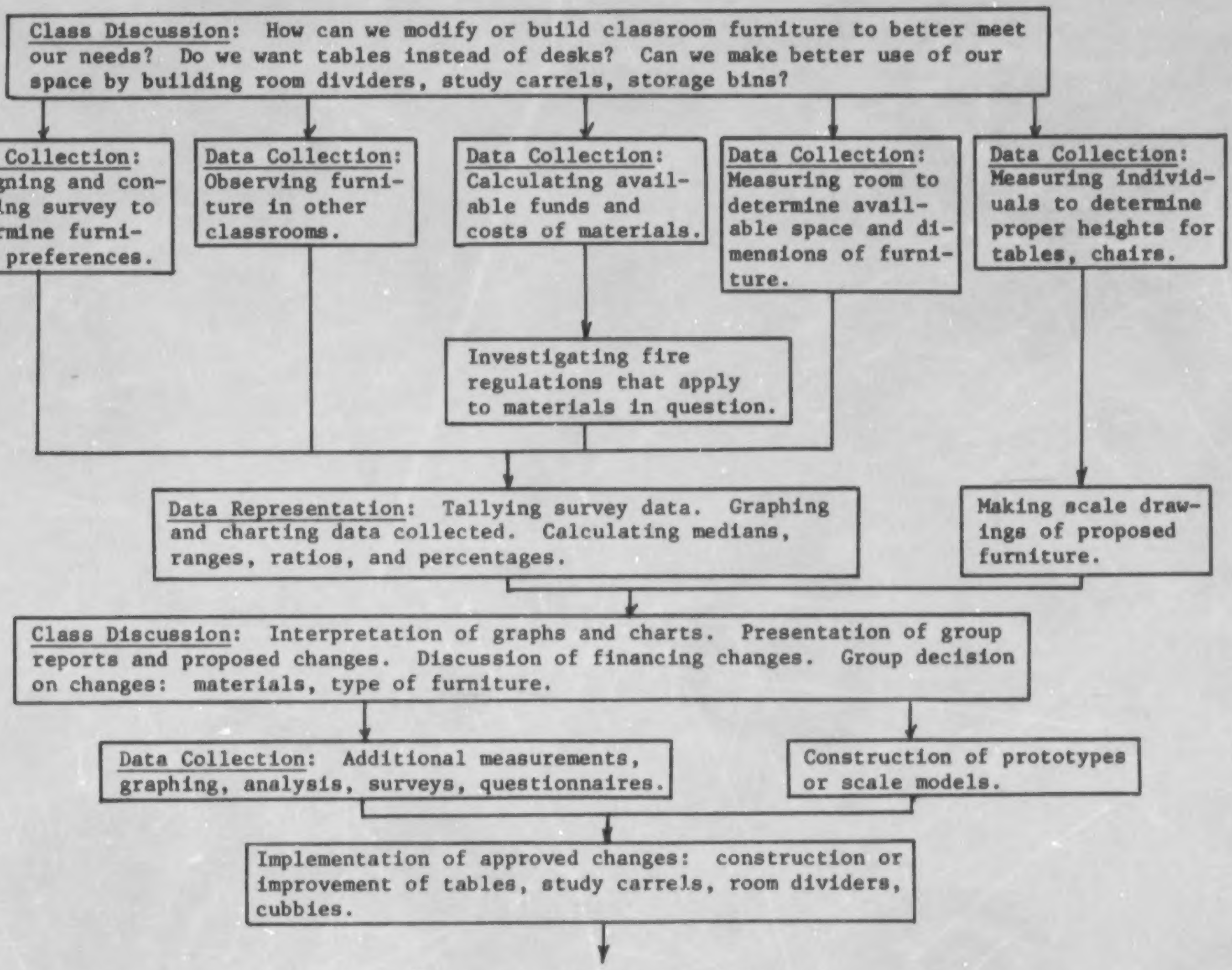
Class Discussion: Interpretation of graphs. Presentation of group reports and models. Group decision on proposed changes.

Implementation of approved changes: new seating arrangement, interest areas, storage area.

(Return to main flow chart.)

FLOW CHART C

Furniture Design



Class Discussion: How can we modify or build classroom furniture to better meet our needs? Do we want tables instead of desks? Can we make better use of our space by building room dividers, study carrels, storage bins?

Data Collection: Designing and conducting survey to determine furniture preferences.

Data Collection: Observing furniture in other classrooms.

Data Collection: Calculating available funds and costs of materials.

Data Collection: Measuring room to determine available space and dimensions of furniture.

Data Collection: Measuring individuals to determine proper heights for tables, chairs.

Investigating fire regulations that apply to materials in question.

Data Representation: Tallying survey data. Graphing and charting data collected. Calculating medians, ranges, ratios, and percentages.

Making scale drawings of proposed furniture.

Class Discussion: Interpretation of graphs and charts. Presentation of group reports and proposed changes. Discussion of financing changes. Group decision on changes: materials, type of furniture.

Data Collection: Additional measurements, graphing, analysis, surveys, questionnaires.

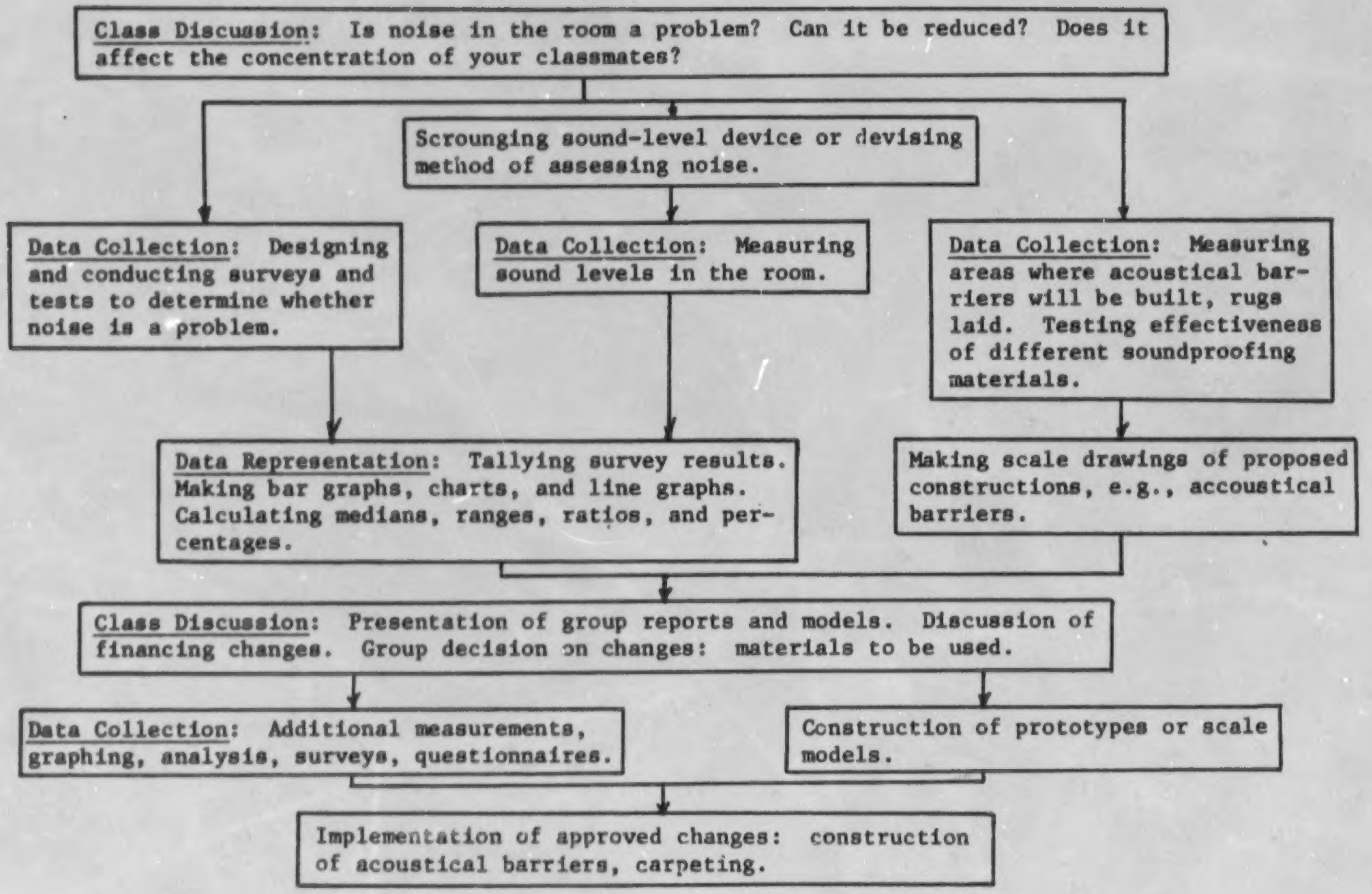
Construction of prototypes or scale models.

Implementation of approved changes: construction or improvement of tables, study carrels, room dividers, cubbies.

(Return to main flow chart.)

FLOW CHART D

Sound



Class Discussion: Is noise in the room a problem? Can it be reduced? Does it affect the concentration of your classmates?

Scrounging sound-level device or devising method of assessing noise.

Data Collection: Designing and conducting surveys and tests to determine whether noise is a problem.

Data Collection: Measuring sound levels in the room.

Data Collection: Measuring areas where acoustical barriers will be built, rugs laid. Testing effectiveness of different soundproofing materials.

Data Representation: Tallying survey results. Making bar graphs, charts, and line graphs. Calculating medians, ranges, ratios, and percentages.

Making scale drawings of proposed constructions, e.g., accoustical barriers.

Class Discussion: Presentation of group reports and models. Discussion of financing changes. Group decision on changes: materials to be used.

Data Collection: Additional measurements, graphing, analysis, surveys, questionnaires.

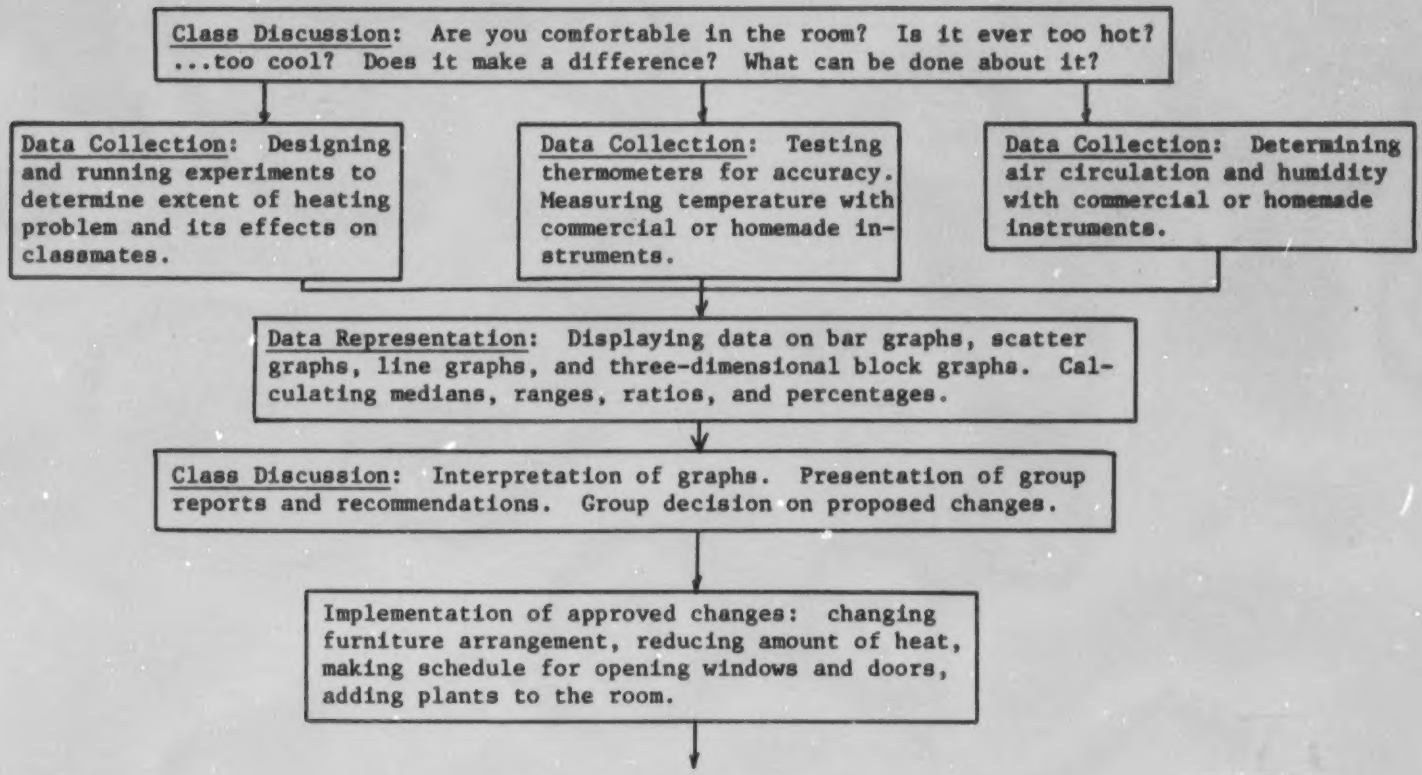
Construction of prototypes or scale models.

Implementation of approved changes: construction of acoustical barriers, carpeting.

(Return to main flow chart.)

FLOW CHART E

Heating



Class Discussion: Are you comfortable in the room? Is it ever too hot? ...too cool? Does it make a difference? What can be done about it?

Data Collection: Designing and running experiments to determine extent of heating problem and its effects on classmates.

Data Collection: Testing thermometers for accuracy. Measuring temperature with commercial or homemade instruments.

Data Collection: Determining air circulation and humidity with commercial or homemade instruments.

Data Representation: Displaying data on bar graphs, scatter graphs, line graphs, and three-dimensional block graphs. Calculating medians, ranges, ratios, and percentages.

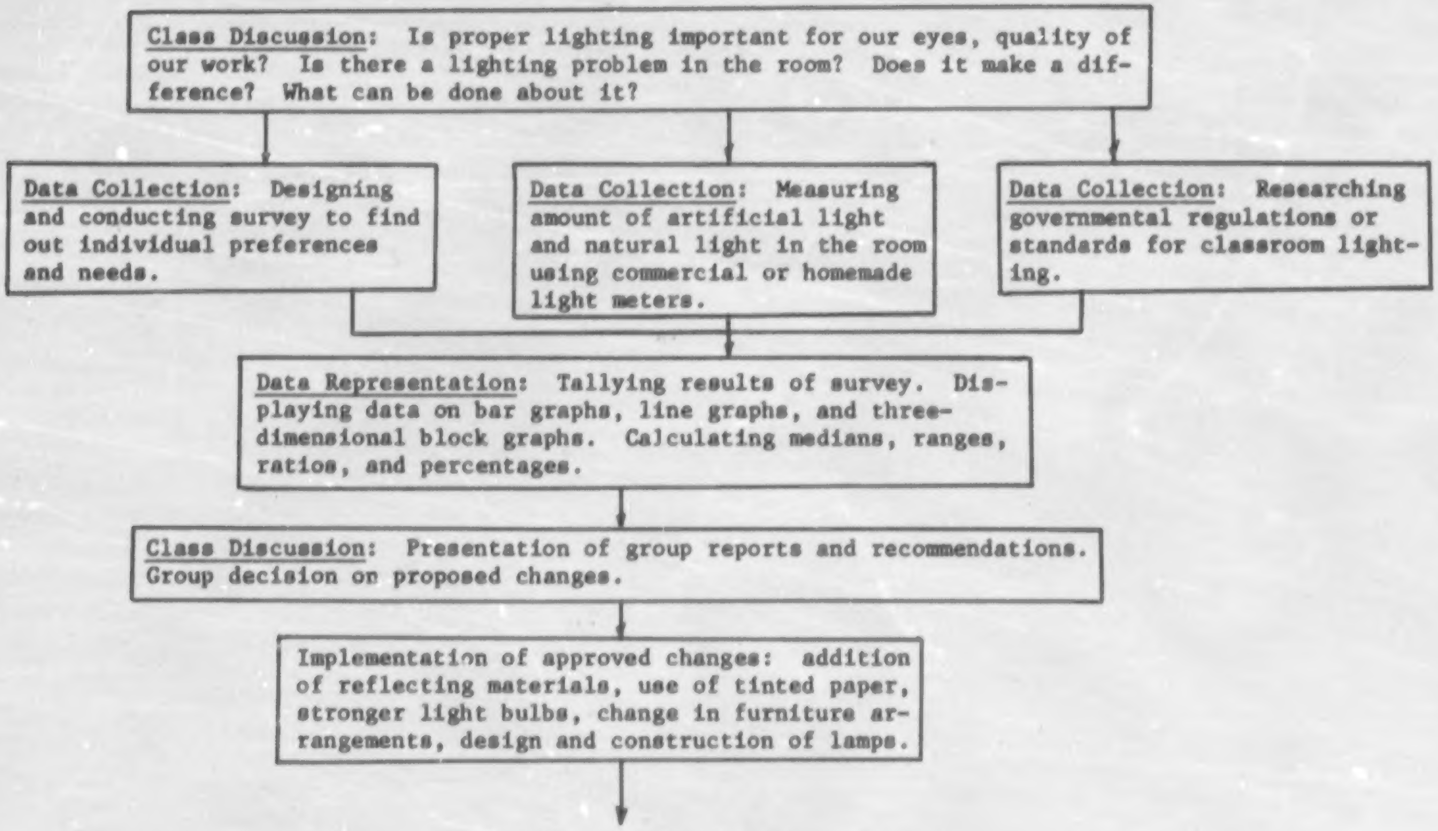
Class Discussion: Interpretation of graphs. Presentation of group reports and recommendations. Group decision on proposed changes.

Implementation of approved changes: changing furniture arrangement, reducing amount of heat, making schedule for opening windows and doors, adding plants to the room.

(Return to main flow chart.)

FLOW CHART F

Lighting



Class Discussion: Is proper lighting important for our eyes, quality of our work? Is there a lighting problem in the room? Does it make a difference? What can be done about it?

Data Collection: Designing and conducting survey to find out individual preferences and needs.

Data Collection: Measuring amount of artificial light and natural light in the room using commercial or homemade light meters.

Data Collection: Researching governmental regulations or standards for classroom lighting.

Data Representation: Tallying results of survey. Displaying data on bar graphs, line graphs, and three-dimensional block graphs. Calculating medians, ranges, ratios, and percentages.

Class Discussion: Presentation of group reports and recommendations. Group decision on proposed changes.

Implementation of approved changes: addition of reflecting materials, use of tinted paper, stronger light bulbs, change in furniture arrangements, design and construction of lamps.

(Return to main flow chart.)

5. A COMPOSITE LOG*

This hypothetical account of an intermediate-level class describes many of the activities and discussions mentioned in the flow chart. The composite log shows only one of the many progressions of events that might develop as a class investigates the Classroom Design challenge. Documented events from actual classes are italicized and set apart from the text.

Overactive radiators in a fourth-grade classroom evoke complaints from some students: "It's too hot on this side of the room; may we change our seats?"

After allowing a seating change, the teacher asks the students whether they have other gripes about their room. At first the children hold back, but when the teacher points out that they can indeed make changes, the class comes to life.

"Tables would be more fun than desks to sit at."

"The bulletin boards are really dull, we ought to paint them a nice color."

"I can't tell what's on the board when the sun is shining on it." Other children express interest in rearranging and redesigning the furniture.

> *In one sixth-grade class in Arlington, Massachusetts, some children complained that during seven years of school only once (in kindergarten) had they had the opportunity to sit at tables rather than desks. Many children wanted to replace their desks with tables. (See log by Bernard Walsh.)*

> *Children in a sixth-grade class in Lexington, Massachusetts, felt that their classroom was too bare. They wanted to decorate to make it more attractive. They believed that they would learn better and be happier if their environment were improved. (See log by Robert Farias 9/73 - 3/74.)*

The children delve into the pros and cons of having tables rather than desks. "If we got tables, our papers wouldn't slide off, and we could sit closer to what we were doing."

Several children wonder about getting money for new tables, but one student mentions the possibility of building tables or fixing up old ones that could be scrounged.

The teacher writes on the board a list of the children's ideas; as the discussion continues, the list grows. Noise, uneven lighting, lack of a study area, disorganized art supplies are all cited as problems.

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*Written by USMES staff

IMPORTANCE OF PROBLEMS

	TEMPERATURE	APPEARANCE	FURNITURE	NOISE	LIGHT
5	6·5=30	2·5=10	11·5=55	0·5=0	6·5=30
4	2·4=8	4·4=16	8·4=32	1·4=4	10·4=40
3	3·3=9	8·3=24	5·3=15	3·3=9	6·3=18
2	8·2=16	10·2=20	1·2=2	3·2=6	3·2=6
1	6·1=6	1·1=1	0·1=0	18·1=18	0·1=0
TOTAL	69	71	104	37	94

Figure B5-1

"How will you work on all these things?" the teacher asks. By grouping certain problems, the children end up with five categories:

1. furniture and arrangement
2. appearance (decoration and organization of supplies)
3. noise
4. lighting
5. temperature

After the teacher asks the children which problems they should work on first, one student responds, "We can vote to find out the important ones and work on those first."

The children are eager to hear about and try a ranking/voting procedure mentioned by the teacher. Each student ranks the choices from five to one, giving a five to the problem he or she considers most important, a four to the next most important, and so on.

"How many gave a five to furniture and arrangement?" asks the student who has volunteered to compile the scores on the board. Eagerly, many of the children multiply by five the number of hands raised; the compiler writes the result. By asking how many gave it a four, a three, a two, a one, the compiler gets a total score for furniture and arrangement. Figure B5-1 shows the scores for all five categories.

Each child selects one of the two problems on which he or she wants to work. Then the class discusses the goals and tasks of the two groups:

Furniture and Arrangement Group

1. Find out who wants to sit at tables.
2. How can we build or buy furniture?
3. What kind of furniture and how many should we get?
4. Make a seating arrangement so that everyone is happy.

Lighting Group

1. Fix the glare on the board.
2. Make the lighting even so it's fair for everybody.
3. Measure the light in the room to find out what to change.
4. Measure the light again later to make sure the problems are solved.

Children in the Furniture Group devise and conduct a survey to find out about their classmates' preferences regarding tables and desks. The results show that eighteen students want to sit at tables and seven wish to remain at desks. The group discovers a potential dilemma in seating arrangement; several children want to sit next to the same person.

> *In the Lexington class, a survey about desk/table preferences showed that several children wanted to sit next to the same person. The class discussed the problem in terms of sets, using Venn diagrams to illustrate intersections of sets of pairs.*

The group cannot decide how many tables to make, because the number needed depends on the seating capacities of the tables. To get ideas for sizes and designs, the children visit other classrooms in the school.

Impressed by the sturdiness of a Tri-Wall table in one room, the group decides to build something similar that will seat six people comfortably.

> *Children in the Arlington class conducted a survey to see which types of tables teachers in the school preferred. Among the choices in the survey was a kidney-shaped table that the children had observed in another classroom. This table received the most votes. One child built a scale model and explained to the class how such a table could be constructed. The class decided to build a prototype and planned to construct two more if they were pleased with the first. (See log by Bernard Walsh.)*

> *Students in another sixth-grade class in Arlington, Massachusetts, asked for tables to replace some of the desks in their classroom. The tables they received had badly scarred tops and were in poor condition. The students removed the tops, turned them over, scraped off the gum, and sanded and washed them. Then they sanded and painted the sides of the tables. The students painted the tops with chalkboard paint; the tops could then be written upon*

> *with chalk and erased easily. They decided that four children would sit at each table, and they removed several desks to make room for the new furniture. (From log by Michael McCabe.)*

While some group members begin designing a prototype, others handle such details as checking with the Design Lab manager about availability of Tri-Wall and conferring with the principal and custodian about possibilities for storing desks somewhere in the school building. Some children who telephone the Fire Department learn that regulations prohibit Tri-Wall furniture in classrooms unless the tables are coated with fire-retardant paint and their edges sealed with duct tape. This information is passed on to the table designers. Other information, about aisle space and exit clearance, is saved until the children work on the room layout.

> *Officials from the Fire Department ordered the removal of the Tri-Wall tables that one of the Arlington classes had built, because the structures did not meet fire regulations. The children discovered that the tables could remain if painted with fire-retardant paint and if the edges were sealed with duct tape. Each child contributed twenty-five cents to pay for the table-saving materials. (See log by Bernard Walsh.)*

One group member's experience with the Designing for Human Proportions unit proves helpful for designing tables. She suggests a procedure for finding out what table height each child prefers. While a student sits in a chair, two members of the group gradually raise and lower a Tri-Wall sheet until the student picks the height he or she likes best. A third group member reads the height directly off a meter stick he is holding vertically.

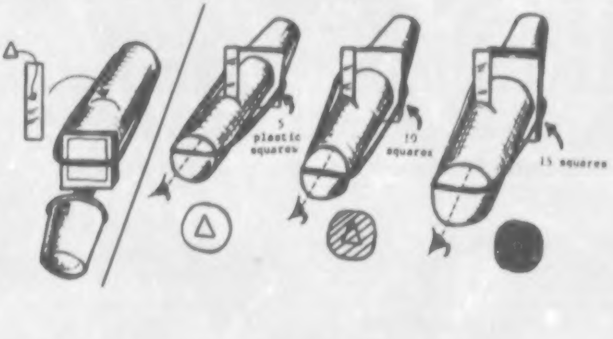
Analysis of the height preferences raises the question of whether to make all three tables the same height or different heights. For ease of manufacturing and to ensure that anyone could sit at any table, the children choose to build all tables alike; they use the median of the preferences as the single height.

To determine the other dimensions of the tables, the children assume that one desk area will be sufficient for one student. By adding six such areas--two on each long side of the table and one on each short side--they arrive at length and width figures for their table design.

The Lighting Group faces two related problems. Glare on the chalkboard can be readily solved by drawing the shades, but the result is a dim and unevenly lighted room because of the old lighting system in the building. The children discuss the factors that might account for one section of the room being lighter or darker than another. One child blames a dark wall in one corner for that section's dim lighting. Another child says that the desks directly underneath ceiling lights are the brightest when the shades are pulled; those near the window are brightest when the shades are up.

> *Children in a sixth-grade class in Lexington, Massachusetts, believed that their work suffered because the sun shone in their eyes and created glare on the chalkboard. Closing the shades left the room too dark. The class felt that students in the brighter portions of the room had an unfair advantage when everyone worked on the same activity. (From log by Robert Farias 1/73 - 3/73.)*

The Lighting Group wants to measure how well-lighted different portions of the room are under different conditions. With help from their teacher, the children construct a light-measuring device from a cardboard tube and blue plastic report covers. A small triangle and a strip are cut from the plastic and attached as shown in the sketch below. By peering through the tube, the operator of the device can clearly see the triangular shape glued onto the strip inserted in the tube. Plastic squares, large enough to cover



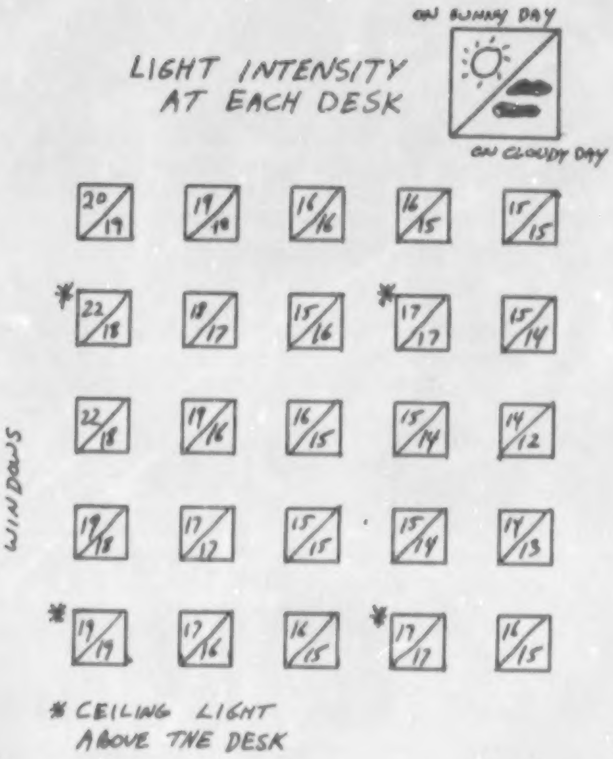


Figure B5-2

the end of the tube, are added one-by-one until the small triangle can no longer be seen. The number of squares needed to obscure the triangle is a measure of the brightness of whatever is being looked at through the tube.

Because everyone in the Lighting Committee wants to help construct the light meter, the children form three groups, each to build its own instrument. The students agree to "build them all exactly the same" to ensure that all measurements will be standardized.

To check whether the three devices give the same reading under identical conditions, three children simultaneously measure the brightness of a poster on the wall. The children decide that the results (15, 15, and 16) are close enough for their purposes since they plan to take the median of three readings for every measurement.

Discussions about what and how to measure become quite involved. The children finally agree that what they want to determine is how well lighted each student's work area is.

"We can aim the light meter at each desk and make our measurements that way," suggests one child. The teacher asks whether the distance from the desk matters; a student responds that they should play it safe by making all measurements at a distance of two feet above the desk. The rest of the group approves.

Carrying this standardizing procedure one step further, a student recommends placing a sheet of white paper on each desk being measured "because the desks don't all look the same; some are all messed up." This suggestion also gets approved.

Weather adds another variable. The children realize that the room is lighter on a sunny day than on a cloudy day. Also, one child points out that they pull the shades down only on sunny days because there's no glare on the board when it's not sunny. Two sets of measurements are planned: one set on a cloudy day with the shades up and one on a sunny day with enough shades drawn to eliminate glare on the board.

Following a three-day sunny spell, rain is greeted with enthusiasm by half the class as the children complete their measurements and enter their data on a chart (see Figure B5-2). To present the numbers in a meaningful way, the group plans a pair of three-dimensional graphs; one for cloudy-day measurements and one for sunny-day data. Each graph will be a scale drawing of the classroom on which stacks of poker chips will be placed. For a desk whose brightness is fifteen, the children will appropriately place

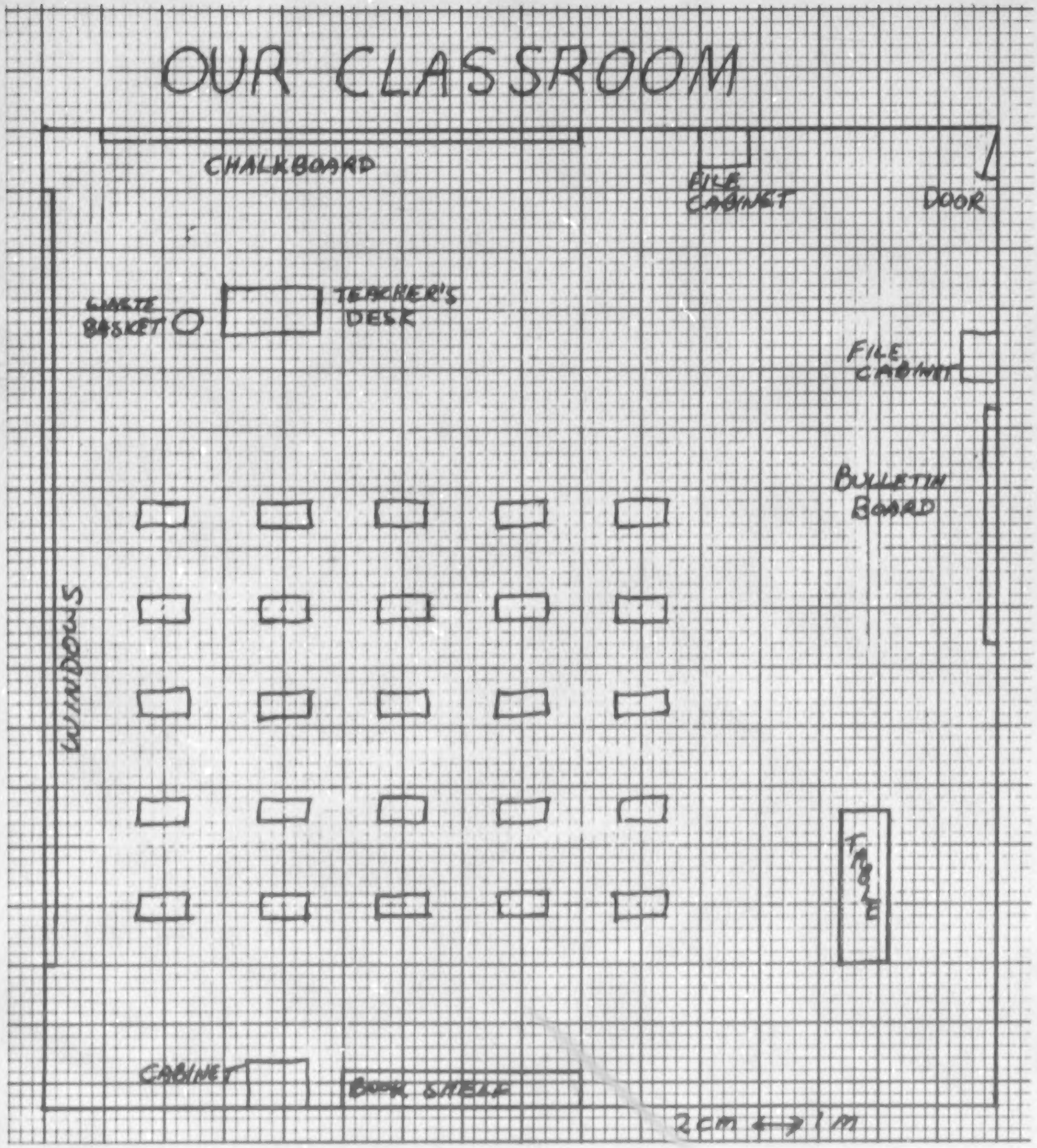

OUR CLASSROOM
CHALKBOARD
FILE CABINET
DOOR
WASTE BASKET
TEACHER'S DESK
FILE CABINET
BULLETIN BOARD
WINDOWS
TABLE
CABINET
BOOK SHELF
2cm ↔ 1m

Figure B5-3

a fifteen-chip stack on the scale drawing. After doing this for each desk, the children will be able to see how the brightness varies in the room.

Problems in making a scale drawing arise before the children get very far. After a small debate, they decide to measure only widths and lengths, not heights, of things in the room (and the room itself). Students desks are a meter wide according to one child, but eighty centimeters wide according to another. The pair discovers the source of the discrepancy: one child has rounded off his measurement to the nearest ten centimeters; the other, to the nearest half meter. Measurements proceed after the group agrees to round off all dimensions to the nearest tenth of a meter.

One problem ends, another begins. Room dimensions are 10.5 m by 10.1 m and the children choose a scale whereby one centimeter on their graph paper stands for ten centimeters.

"Our paper is too small!" exclaims one student. At first the children want to tape several sheets together, but after some questioning by their teacher, they decide to try another scale. Through trial and error they arrive at a scale of two centimeters to one meter; their drawing fits nicely on their paper (see Figure B5-3).

One group in the Arlington class measured the classroom and the furniture in it. To make sure they remembered which dimensions went with which furniture, the children recorded their numbers on a sketch of the room. In the Design Lab, they made a scale layout of the classroom with the help of "How To" Cards on making scale drawings. The scale layout enabled the students to anticipate and prevent problems that might have arisen from their rearrangement of the classroom furniture. (See log by Bernard Walsh.)

On two copies of their scale drawing the children stack blocks according to the light-intensity data they have collected. The graphs confirm that on an overcast day the brightest desks are those directly under the ceiling lights, whereas on a sunny day students near the windows benefit from the most light.

Children in the Lexington class used a flashlight and sheet of paper to assess light intensity in dif-

> *ferent parts of their room. Starting from as far away from the flashlight as possible, the students slowly moved the paper towards the light source until they could see the light on the impromptu screen. They then measured the paper-to-flashlight distance; a shorter distance indicated a brighter portion of the room. Because the children felt that this technique yielded inaccurate results, they remeasured using a borrowed, photographic light meter. Based on the new data, the students rearranged their desks according to how much light each child wanted. The children also built desk lights, some of which switched on automatically when the desk top was lifted. In addition, light-colored construction paper placed on some walls helped brighten a dark corner of the classroom. (From log by Robert Farias 1/73 - 3/73.)*

"We can make lamps for some of the desks to brighten them up, then the lighting will be the same all over, even when we close the shades to keep the sun off the chalkboard," one student suggests.

Excited by this idea, the group wants to begin at once to design desk and table lamps. The children, however, soon become immersed in a debate about how bright the lights should be and whether there are laws concerning classroom lighting.

"How can you find out about such things?" the teacher asks, prompting a long discussion that ends with a few students volunteering to call a local architectural firm for assistance.

When an engineer from the company visits the class several days later, the class discovers how complicated lighting can be. The visitor explains how different tasks require different amounts of light and lists some classroom lighting standards. She then demonstrates a professional light meter and examines the homemade instrument that the children have used. She also recommends that the children check with their principal or the school board before building their lamps.

Before going to the principal for approval, members of the Lighting Group decide to first solidify their ideas into a definite plan. They agree that the lamps must run on batteries because a network of wires on the classroom floor would be hazardous. They also anticipate questions from the principal about funds for the project; they decide that if they need materials that are unavailable in the Design Lab, they will ask their parents and other people to donate supplies.

Thanks to the children's foresight, the principal gives his approval. Eagerly, the children go to work. They examine the Design Lab inventory and make a list of items that might prove useful. They learn from the Design Lab manager that they will be able to use the battery charger in the lab to recycle batteries for their lamps. They send notes to parents, teachers, and local businesses asking for batteries, bulbs, old flashlights, and used lamps. They confer with the Furniture Group to make sure that any table lamps they build will be compatible with the new tables.

Children in the Lighting Group also find out which students will remain at desks. Then, after designing a few models of lamps, they ask each student to choose the one he or she prefers.

Some children feel that battery-powered lamps will not give off enough light. "We can use brighter bulbs and more batteries," suggests one student. Others recommend that the class try to figure out a more permanent solution, one that wouldn't require much upkeep.

"What about tinting our windows like in cars," one girl suggests.

Another says, "My mother has see-through curtains; they seem to let in a lot of light, but they might cut out the glare." The children decide to try the drapes approach first because it's easier; they agree to see whether their parents can donate suitable material.

Three students bring in material the next day. After each sample is held up to the window, the class selects a yellow fiberglass curtain as the best glare reducer. Three members of the Lighting Group volunteer to measure the windows and cut and sew the curtains to fit. Others say they can bring in curtain rods. Work on the lamps continues as well, but the children now consider their homemade lights an extra rather than the main solution.

Making curtains for their classroom turned out to be an elaborate venture for children in a sixth-grade class in Washington, D.C. They measured the windows to determine how much material they would need; they doubled the measurements because they wanted fuller curtains. Choice of material was limited by a local

> *ruling; the children had to select a sheer material because classroom lights could not be on during sunlit days. The group purchased suitably translucent material (and curtain rods). The students sowed the curtains in the classroom, using a sewing machine that the class had obtained during work on another USMES unit. On two of the ten windows, the children made and hung full-length curtains; on the remaining eight, they sewed and hung valances. These short curtains allowed sufficient light from outside to enter the room. (From log by Jeanette Lea.)*

Meanwhile, the Furniture Group has completed its prototype table and is now ready to test it for durability, usefulness, and appearance. After agreeing on a trial period of one week and listing the objectives of the test, the group members split into two committees: one to handle details of the test, the other to recommend an arrangement of tables and desks.

The Table Testing Committee selects children to try out the table for a week, drafts and dittoes an observation sheet, and prepares a questionnaire to find out how everyone in the class feels about the prototype.

As the week of table testing ends, the children realize that the novelty of sitting at a table wears off quickly. Moreover, the prototype is found to be neither as sturdy nor as durable as the wooden desks that the students are used to. The children learn, for example, that several pencil holes have been made in the table top and such holes make writing difficult. "I had to put one of the big books under my paper whenever I wrote," explains one of the testers.

A long discussion about the table leads to a big change in plans. The class decides to keep all the desks. They plan to build the two additional Tri-Wall tables anyway, but the students will use them only when they work in groups or when they have something special to do that requires a large working surface.

The decision to keep all the desks affects the work of the Arrangement Committee. Members of the committee borrow the scale drawing that the Lighting Group made for its three-dimensional light-intensity graphs. The children make cutouts of the movable furniture including the prototype table and the pair to be built. After trying several layouts they arrive at one in which their desks are clustered around each of five ceiling lights. However, when they check the fire regulations they discover that no furniture can be within three feet of the door. By returning the file cabinet to its original spot and shifting one table to the rear of the room, the children figure out an arrangement that meets all regulations and still seems convenient and functional. They present the proposed layout to the class and it is approved. (See Figure B5-4.)

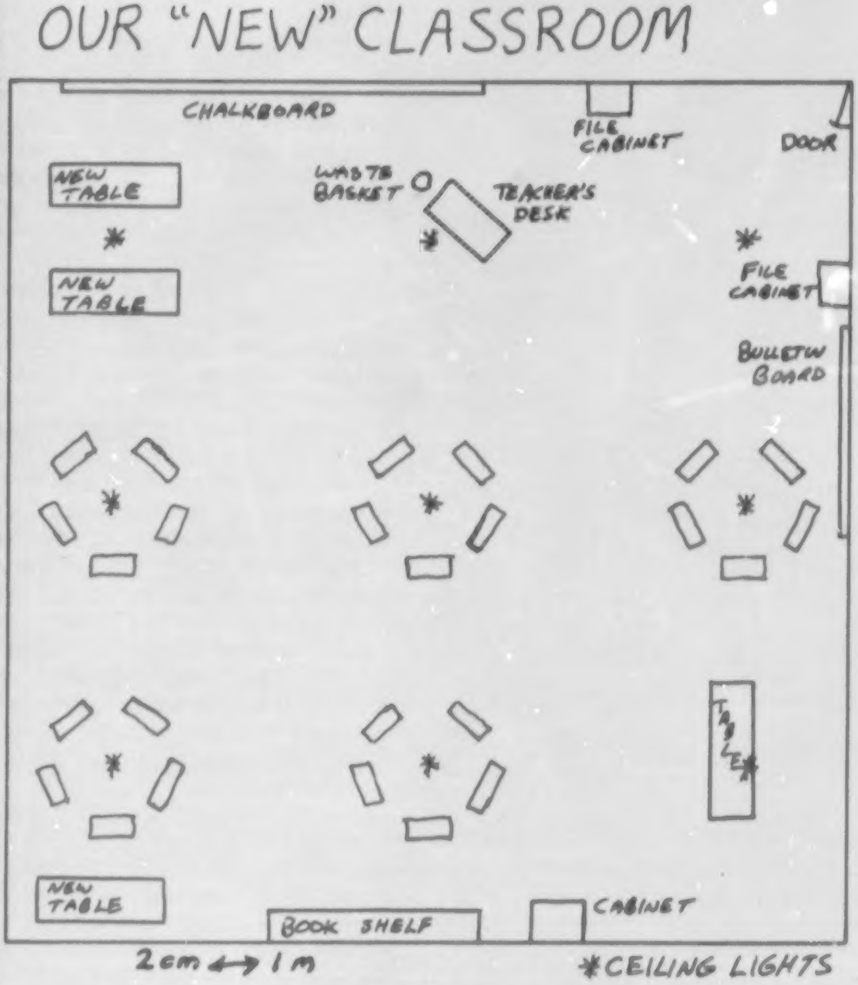


Figure B5-4

Children in the Lexington class revamped the furniture arrangement in their classroom. They clustered their own desks, shifted the teacher's desk to a different corner, set up tables for various activities, and established a quiet, library section in one corner of the room. (From log by Robert Farias.)

A first-grade class in East Lansing, Michigan, examined two floor plans devised by the Room Arrangement Committee. Although the drawings were not to scale, they did indicate two proposed furniture arrangements. After the class voted for one, the committee members moved the furniture accordingly. For example, they relocated the reading center from the rear of the room to the front--nearer to the chalkboard. (From log by Debbie Thomas.)

Construction of desk lamps, table lamps, and the remaining two tables keeps both the Furniture and Lighting Groups absorbed and busy for the next four weeks. When the agreed upon arrangement is implemented, the class discusses how to evaluate the changed classroom.

"We were going to measure the lighting again after we changed everything around," says one member of the Lighting Group. A girl in the Furniture Group says her group just needs to find out whether everyone is happy with the new situation.

Measurements of the light shining on the tables show, as planned, that the three tables are in equally bright positions of the room. Also, the children agree that the curtains sufficiently reduce glare on the chalkboard and may even account for tne improved distribution of light in the room. Those children with desk lamps say that the lights help out and are "nice to have." Lastly, everyone is pleased with the design and placement of the three new tables and with the clusters of desks.

Agreeing that they have met their challenge by solving the lighting and furniture problems, the students decide to tackle the next most important problem, the appearance of the classroom.

6. QUESTIONS TO STIMULATE FURTHER INVESTIGATION AND ANALYSIS

- How much time do you spend in the classroom? How much of your waking hours is this? What do you do in your classroom?
- What are some of the things that you like about the classroom?...don't like about the classroom?
- How can you find out whether most students in the class think these are problems?
- How could you make the classroom a better place in which to work and have fun?
- What kinds of changes would you like to make to improve the classroom?
- Which of these changes should you work on first?
- How could you find out what your classmates think about the changes?
- How could you find out whether lighting (heating, humidity, noise) is a problem in your classroom? How could you measure these variables? What instruments would you need? Where would you get them? How could you build your own?
- What new furniture would you like to have?
- How big should the furniture be? How strong does it need to be? How do you know whether or not your new furniture will fit in the classroom? How can you be sure that everyone in the class will like the new furniture?
- What would you need to build a prototype? Where and how would you get the materials you'll need? Who would pay for them?
- How can you find out what regulations there are about classroom furniture?
- How should the furniture be arranged? How could you try out several arrangements without moving all the furniture around?
- What data would you need to collect?

- How could you organize yourselves to best collect the data you need?
- How could you be sure that your data was accurate?
- What does your data tell you?
- What recommendations could you make based on your data?
- How could your recommendations be tried out?
- How could you find out whether your improvements have made a difference?
- What will you do about the problems that you haven't worked on?

C. Documentation

1. LOG ON CLASSROOM DESIGN

by Debbie Thomas*
Pinecrest School, Grade 1
East Lansing, Michigan
(November 1974-March 1975)

ABSTRACT

This first-grade class worked on Classroom Design from November 1974 to March 1975, usually spending two to three hours a week working on the challenge. The children were very eager to improve their classroom and divided into groups to work on six areas: (1) room arrangement, (2) noise, (3) floors, (4) teacher's desk, (5) organizing the art center, and (6) organizing the games. To avoid the difficulties that stemmed from working with so many groups, the teacher arranged to have only one group working at a time. Working in committees, the children surveyed the class to find where people wanted to sit, rearranged the desks and furniture; tidied and organized the teacher's desk; made cubby holes for art supplies; divided a table into sections to organize the games; made extra Tri-Wall wastebaskets; made a "quiet house" and study carrels; and received, as donations, material for pillows and a carpet. Also, rules were made for using the art center and keeping the room quiet. The children were very pleased with their achievements and thought their classroom was much more pleasant. However, they thought they might want to change things again if they got tired of the new arrangement.

We began the Classroom Design unit by discussing problems we were having in the classroom. The children were particularly upset at the lack of order in the seating arrangement. The custodian moved their seats every night, and the children changed their minds every day about where they wanted to sit. Moreover, some children chose to sit right by the door, making it difficult to get in and out of the classroom. They also complained that the games were all mixed up in a pile on one table and that the room lacked a quiet area.

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*Edited by USMES staff

After we had discussed these problems for a bit, I asked the class if they thought there were ways we could make this a better classroom in which to learn. The children immediately said yes, and because I wanted them to feel it was their problem, I told them I was going to get some coffee and they could tell me what they had decided to do when I returned. Ten minutes later I came back to find one girl trying to attract everyone's attention, and the rest of the class all talking at once. They complained about this disorder, and so I helped them to get organized. I asked them what specific things they wanted to work on, and we divided their responses into six different categories:

1. room arrangement
2. noise
3. floors
4. teacher's desk
5. organizing the art center
6. organizing the games

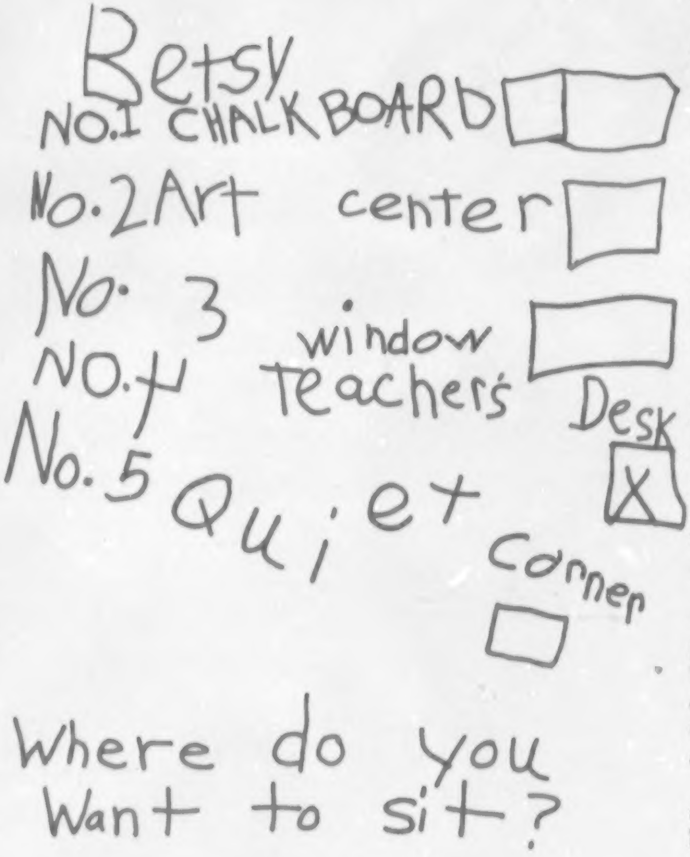
Each child chose one of these areas to work on, and then we talked about making committee decisions. "What if one committee decides to move all the desks out of the room?" I asked.

"That's not fair, I want a desk," someone objected. This reply led us into talking about decision making and the importance of surveying before making important decisions that will affect others.

At the next session we reviewed the challenge and went over the list of members for the committee. Then the groups met separately to start their investigations, and I circulated among the groups. The children were so eager to go ahead and solve their problems that they were not always stopping to plan carefully. However, by the end of the period every committee had a picture list of the materials they needed, some of which they planned to get at home and some they wanted me to get.

During the next three months the children worked in their committees, at first during scheduled USMES times but later at times they chose themselves. Because we did not have many tools and because I often needed to be with several groups, (for example, to give skill sessions on measuring), I found it easier if only one committee worked at a time. This worked out for the children too, because they were used to scheduling their own day.

The main problem we ran into was a lack of materials--



Betsy

NO.1 CHALKBOARD ☐

No.2 Art center ☐

No. 3 window ☐

NO.4 Teacher's Desk ☒

No.5 Quiet corner ☐

Where do you Want to sit?

Figure C1-1

nearly all the groups were held up at one time or another for lack of Tri-Wall or other construction materials. Although this discouraged them at the time, their enthusiasm returned as soon as the materials become available.

For clarity I will report the activities of each group separately. The Room Arrangement Committee designed a survey to find out where the students wanted to sit (see Fig. C1-1). I showed the children how to make a ditto and run it off, and they counted how many copies they made to avoid wasting paper. They distributed the surveys to the class and collected them at the next session. When they tallied the responses, they found that fifteen children wanted to sit by the teacher's desk. Because there wasn't room for this number, they had to find a method for choosing. They suggested three methods: making a sign-up sheet, drawing straws, and letting me decide. By vote, the class decided to have a sign-up sheet and to change every month.

Next, the committee planned where to put the rest of the furniture. They consulted the Noise Committee and the Teacher's Desk Committee about where to put the reading center and the teacher's desk. Then they divided into two sub groups; each devised a floor plan for a new furniture arrangement. These floor plans were not drawn to scale. The two proposals were presented to the class, which then chose one by vote.

At our next session the Room Arrangement Committee moved the furniture in accordance with the chosen floor plan, giving those who had wanted to sit near the teacher's desk, but couldn't, their second choice of where to sit. The children moved the reading center from the back of the room to the front so that it was near a chalkboard, and they agreed they would like a carpet for the quiet corner.

They asked the principal about a carpet. The principal said he had no money to buy one, but the custodian might have some scrap carpet. The custodian did indeed have a small, rather shabby, piece which we thought could be trimmed up. One boy offered to ask his mother about some unused carpet in their basement. At the next session another boy said that his father, who owned a carpet store, would get us a new carpet free, and we could even choose the color. Very excited about this, the children decided not to use the custodian's carpet. They voted for a color --gold--and then wrote letters to the father to explain how they planned to use the carpet. It arrived quickly, and the Room Arrangement Committee put the carpet in the quiet center and arranged the center, including a shelf of books

on one edge, a partition on the other, and a reading table and some quiet games. We talked about bringing pillows to lie on and someone suggested that we make some large ones, but nothing was done about this for a while. The children wrote thank-you letters to the father who had donated the carpet.

Meanwhile, the Noise Committee made twenty-four "quiet" signs and posters, with such phrases as "Quiet Please," "Author at Work," and "Shhhh-Reading." They hung these at various places around the room from walls, tables, and the ceiling.

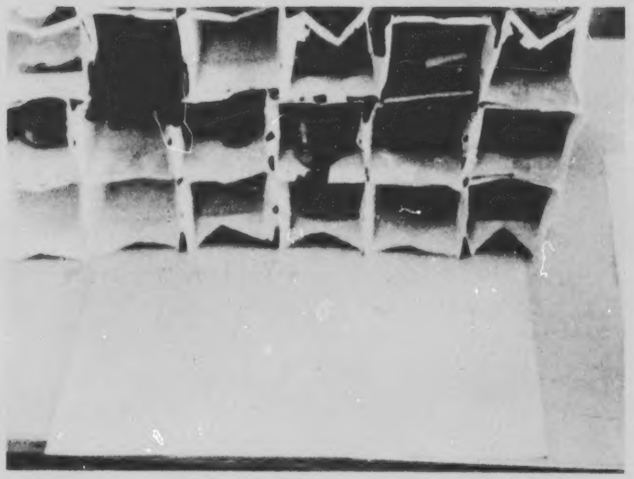
They thought they should make a quiet box (anyone entering the box would have to be quiet). Although they had planned to use a refrigerator box for their structure, the children used instead a purchased corrugated-board "house" that they had put together. They cut out windows and decorated the outside.

Another project, the construction of five study carrels, took longer. Measuring the desks and the Tri-Wall involved learning how to use the meter stick. Furthermore, the children surveyed the class to find out what color to paint the carrels.

The Floor Committee spent most of their time constructing wastebaskets because ours were always too full. They considered surveying the class to see where the new baskets should be placed, but became involved in the construction activities instead. Designing and building the wastebaskets required many measurement skills. Quite a lot of the children's time was spent mastering these skills in small group sessions. They were also held up for a time by a lack of Tri-Wall. During their wait, the students made a chart showing who would be responsible for checking the floors each day before dismissal.

The Teacher's Desk Committee started by cleaning my desk. The children made a clearly marked container for handed-in papers (some children had been confused about where to hand in papers). Next they used a silverware divider to sort all my brass fasteners, paper clips, etc. After asking me how I felt about students being able to get into my desk, they decided that I should have one private drawer. They labeled one accordingly. After consulting with the Room Arrangement Committee, they decided to move my desk to the center of the room so that more people could sit around me. This group soon ran out of things to do with the teacher's desk; the members disbanded and joined other committees.

Children in the Art Center Committee decided that students needed (1) tote trays to carry materials to their



desks and (2) paint containers. They wanted to survey the class to see which art materials were used most, so these could be kept handy. They sorted all the materials and measured the area we had to store them in. They sketched their designs for tote trays, but a lack of materials held up construction. Instead they designed and made cubby holes for storage out of half-gallon milk cartons that they stuck together. They had decided to use each carton for a different art supply--crayons, chalk, yarn, spools, watercolors, scrap paper, material, and straws. No one would have to go to my supply closet, since one person each week would be in charge of keeping the cubby holes supplied. Next to the cubby holes, the children hung a list of new rules concerning the use of the art center.

The Games Committee planned to make a shelf on which to store the games, sorted by different types. They drew two possible designs on newsprint. After I asked them what they would do if they made the shelves too small for some of the games, they decided to measure all the games before building shelves. However, none of them knew how to use a meter stick; they just pretended and didn't record anything. Since materials were unavailable at this time, the children didn't have to come to grips with measurement for a while. While waiting for materials, the group made tags to be glued to the shelves to identify the different types of games.

When the Tri-Wall arrived, the group started cutting out the shelves without much planning or measuring, and consequently, the shelves did not fit together. We discussed what to do to make the shelves fit, and one child said, "Maybe we could draw a picture of what it should look like and how long and high it should be." Since by then they had had some lessons on using the meter stick, they proceeded to measure the games. The largest game was 3 ft. by 2 ft., so they decided that one shelf had to be that big. Unfortunately, the group never did get their shelves right and instead decided to divide the game table into different sections.

Just before the winter vacation we ran into a new problem. All the desks, furniture, signs, etc., had to be taken out of our room to allow for floor waxing and cleaning during the vacation; it seemed that all our work on room arrangement might be lost. We discussed this as a class and then broke into three groups, each of which was to come up with a proposal to solve the problem. The class voted to combine the ideas of all the groups.

We sent a representative to ask the custodian to come to our room, and the children told the custodian that they really liked the way our room was arranged and it would take them a lot of time to do it all over again. When he explained that he had to take everything out of the room, one child asked, "Will you move it back just where it was?" The custodian replied that he couldn't remember twenty room arrangements, and another child asked, "What if we left you a map of our room and showed you where it should go?" After thinking this over for a bit, the custodian thought he could do it. "But be sure I'll understand it," he emphasized. Six children drew a floor plan of our room on the chalkboard just before the vacation, and we were delighted to find everything back in its proper place when we returned in January.

During January and February the children continued working in their committees. The Room Arrangement Committee discussed the dissatisfaction of many children with the seating arrangement. This group decided to set up a "court," so that if someone had a complaint about where they were sitting, they could sign up for a "hearing." The Room Arrangement Committee would hear the case and decide if the child should be allowed to move.

The Noise Committee presented to the class some simple rules for peace and quiet:

1. Please whisper to your neighbor.
2. Please ask assigned helper for help, not Mrs. Thomas when she's working with someone else.
3. If someone is really noisy write his name on the board.

In the middle of February we had a class discussion of how we were getting on in relation to our challenge and what else we needed to do. The children seemed very pleased with their efforts, even the noise rules worked, although a few names had been written on the board. Someone thought that the quiet area should be more comfortable. We discussed making pillows and decided to send notes home asking for old sheets to tie-dye. This produced a good response and even some extra ready-made pillows.

After we had finished making the pillows, we discussed what we had achieved in our Classroom Design unit. I asked the class if they could remember what the classroom was like before our unit and they said, "Yes, icky!" Then we went through all the things we had achieved: study carrels that were shared nicely, a quiet house that was always in demand, the art center, well-organized games, and a quiet area. Our letters home had resulted in materials for pillows and a carpet, and the class had learned how to use measuring instruments. I asked them if they thought they'd ever have to change anything and they said, "Yes, we'll probably get tired of it," and "We might have to change rules if they don't work." Thus, the children's responses to their Classroom Design challenge turned into an on-going activity.

2. LOG ON CLASSROOM DESIGN

by Janet Sitter*
Michigan Avenue Middle School, Grade 5
Howell, Michigan
(November 1973-May 1974)

ABSTRACT

*This fifth-grade class** worked on making the classroom a better place to live and learn. Out of the many improvements the children suggested, they focused on two: rearranging the furniture and adding the study area. After listing the movable furniture, the students drew pictures of how they wanted the room to look. The class analyzed each proposal, selected one by vote, and moved the furniture accordingly. The children wanted to build a two-story study module as part of their plans for converting an alcove in the room into a study area. After they measured and made a scale drawing of the alcove, the children had difficulty designing a practical module. Instead, they used a published set of plans. They divided the labor by establishing work stations. This procedure also resulted in efficient and organized production. The class used remaining wood to build two additional study modules.*

Our initial discussion centered on the question, "What could we do to this room to make it a better place to live and learn?" This became our Classroom Design challenge. Although the children at first hesitated to make suggestions, they presented many ideas when they realized that changes could indeed be made. The children thought of ways to make the room more of a "living" place: they suggested adding house furniture, carpeting, arm chairs, a kitchen, and a separate entrance. Suggestions concerning the "learning" aspect of the challenge were more realistic:

1. Divide the room into sections
2. Get new window shades
3. Establish a new seating arrangement

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*Edited by USMES staff

**A large percentage of the class was classified as requiring special education.--ED.

4. Decorate walls
5. Get curtains and new books
6. Organize material better
7. Rearrange the furniture
8. Reroute traffic flow within the room

New furniture arrangement took top priority; the class wanted to complete it before the upcoming parent-teacher conferences.

Students discussed pros and cons of suggested arrangements. One child noted that each proposal left out some piece of furniture. I asked the children how we could overcome this problem. Acting on their own suggestion, the students compiled the following list of all movable furniture.

1. 37 students' desks
2. 40 student chairs
3. 1 small chair
4. 2 teacher's chairs
5. 1 teacher's desk
6. 2 file cabinets
7. 2 small tables
8. 1 large table
9. 1 wire rack
10. 2 movable book cases
11. 2 long student desks
12. 1 paper holder
13. 1 basket

We reviewed the list and reviewed our challenge. Afterward, each child drew a picture of how the room should be arranged (see Figure C2-1). Much time, thought, and effort went into these drawings. The class analyzed each proposal, focusing on potential pitfalls. The children selected one plan by a vote and rearranged the room furniture accordingly.*

The class wanted to work next on dividing the room and building a two-story study loft. A chart we had developed (see next page) helped the children establish that priority.

The children combined their two areas of interest: they planned a two-story study carrel for a proposed study area. The area, a large alcove on one side of the room, had to be measured to help answer questions about the size of the carrel and the materials needed for its construction.

After a lively discussion about which measuring tools to use, the children chose the fifty-foot tape to measure the length of the alcove and a tape measure to determine its width. To ensure accuracy, two teams independently measured

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*The children might evaluate the new arrangement, perhaps by conducting an attitude survey, to see whether they have overcome the original problems.--ED.

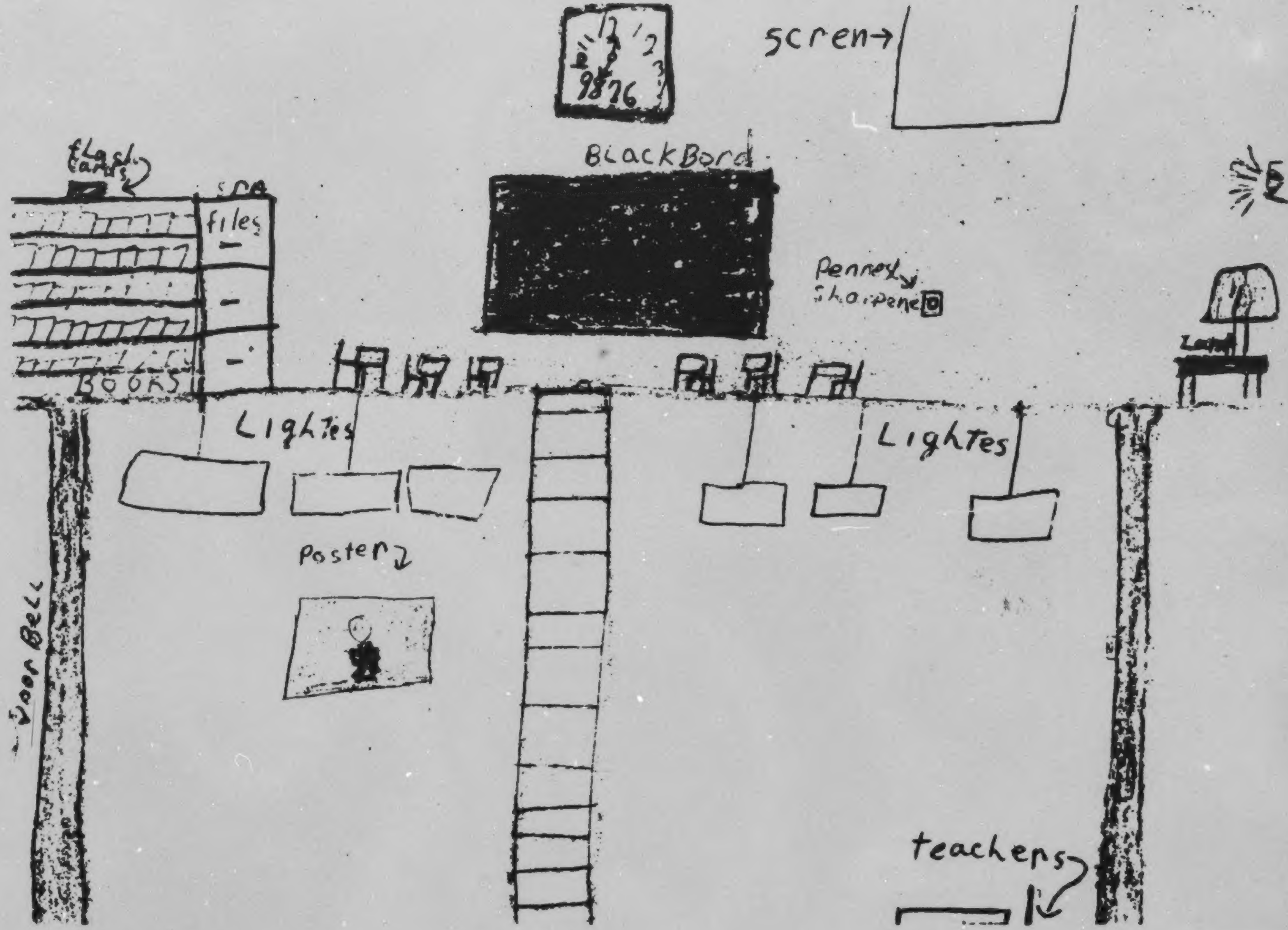

scren→
BlackBord
Flash cards
SRA
files
BOOKS
Pennel sharpener
Lamp
Lightes
Lightes
Poster
Door Bell
teachers

Figure C2-1

Furniture	Materials	Learning
arm chairs		
cushions		
curtains		
divide room		

Why?	How?
-different sections	-divide room in half with curtain
-quiet section	
-reading room	-get rid of empty desks
-ability to move around	-build a two-story loft

How?	Steps
-two levels	-blueprint
-fathers' help	-materials
	where?
	what?
	-build structure
	scrounge

each dimension. The alcove was 18 feet 1 inch by 60 inches. The height, according to the custodian, was between 12 feet and 14 feet. (One student had suggested stacking chairs on desks to measure the alcove's height; another child had suggested we use a ladder. With some prodding from me the children had decided to consult the custodian.)

The children had difficulty comparing the dimensions: the width was expressed in inches, the height in feet, and the length in feet and inches. We developed a conversion chart (below), and from it the children determined that the sixty-inch width could be expressed as five feet.

feet:	1/2	1	2	3	4	5	6
inches:	6	12	24	36	48	60	72

I asked the children whether they could draw the dimensions of the alcove on a piece of paper. They said they couldn't. We talked about the uses of scale drawings and procedures for making them.

First, the children measured the drawing paper--12 inches long. I asked them whether the scale 1" ↔ 1' would work.

They determined that the drawing would not fit on the paper with that scale. One student proposed the scale ½"↔ 1'. Much to the surprise of some children, this scale worked.*

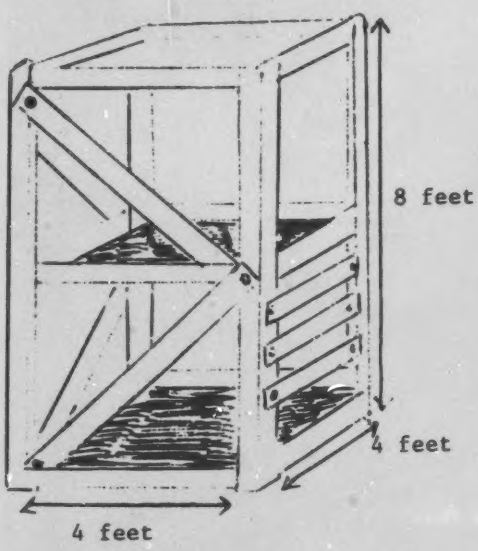
I asked the students to take home their scale drawings to find out whether other people could determine from the drawings and the scale the actual dimensions of the study area.

During the activities on measurement conversion, one student saw the relationship between multiplication and repeated addition. Such discoveries occurred several times during the semester.

The class spent one session trying to make a blueprint of the study module they wanted to build; it was a class project. But the children and I could not come up with a workable design; we were stalled. Another USMES teacher in my area had a copy of *Farallones Scrapbook,* which contained detailed instructions for building a two-story study module. The next week I attended a workshop and went over the instructions with a Design Lab staff member.

On my return, my students and I examined the plans and began to gather the necessary materials. We scrounged enough wood to build two study modules. The wood was not the exact size, however, and had to be cut with a table saw.

Sketch of study module without walls or curtains



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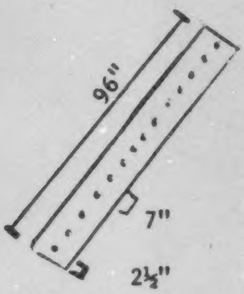
*The children might be referred to the "How To" Cards on scaling and scale drawings. --ED.

Children worked in pairs measuring and marking the wood. Fourteen holes had to be marked for drilling on each column board (see sketch below). Two students checked the measurements for accuracy before drilling the holes. Eight columns were made. Four sets of two columns formed the corners of the frame.



We reviewed our status: wood was sawed, holes were drilled, and we had the necessary nuts, bolts, and washers. While attempting to assemble the frame, the children realized that they were not yet ready to do so. We had no wrenches, the bolts were each a half-inch too long, the boards were slightly warped, the hole positions were not accurate enough, and our construction teams were not yet chosen.

Although the children were unprepared for these discoveries, they recognized the validity of the problems and set out to find solutions. The following suggestions were made and acted upon:

1. Everyone should try to bring a 1/4-inch wrench to school.
2. Ms. Sitter should exchange the bolts for more appropriate ones.
3. The frame should be assembled from the bottom with a hammer being used to tap the warped boards together.
4. Everyone should try to bring saws to cut the beams.

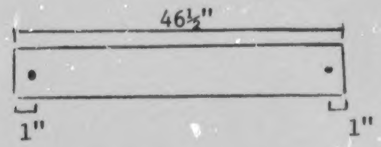
The class disassembled the portions that had been built and stored the materials.

At the next class session, volunteers were assigned duties: drilling, sawing, hammering, measuring, and assembling. We set up work stations, and construction proceeded in an extremely organized and efficient way.

Work Station 1 - A group of boys measured and marked boards. A couple of students checked their work.

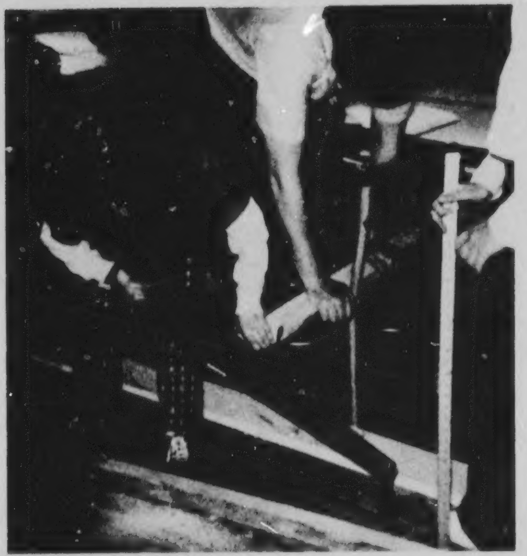
Work Station 2 - A group of students sawed the boards, producing beams 46½ inches in length.

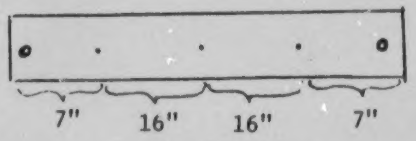
Work Station 3 - A group of children measured and marked the places where holes had to be drilled (for assembling the module). One student checked their work.



Work Station 4 - A group of students drilled holes where indicated on the board.

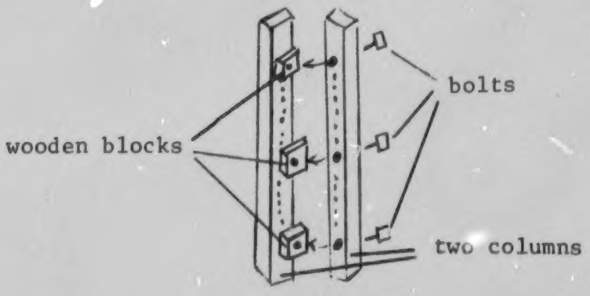
Work Station 5 - A couple of girls measured and marked the positions on the beams where additional holes had to be drilled (for attaching the walls of the module).



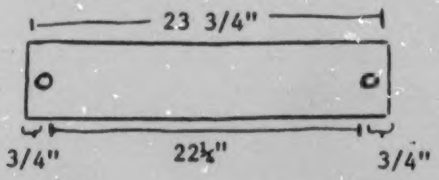


Once the marks were made, the beams went to Station 4 for drilling.

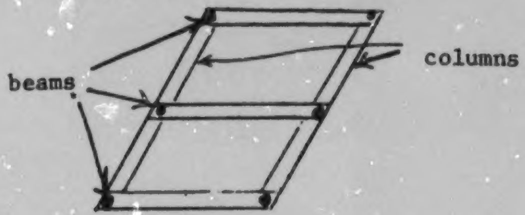
Work Station 6 - A group of students and an adult bolted pairs of columns together.



Students regrouped as different needs were identified. Several students, for example, measured, sawed, and drilled the four stairs for the module.

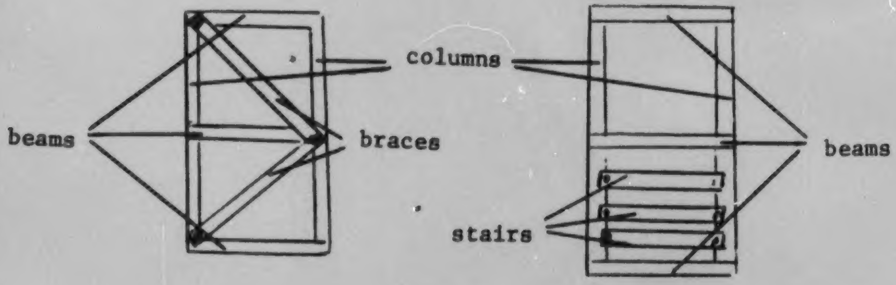


Other children attached pairs of columns with cross beams. Three attempts had to be made before the children were able to bolt the columns and the beams together.



The children began to tighten the bolts in preparation for assembling the four sides of the frame. A problem developed as the children attempted to bolt the third side to the other two; the beams did not fit together because the columns on the third side were warped. Using nails in place of bolts solved the problem.

Groups of children braced two sides of the frame and attached the stairs to one of the unbraced sides.

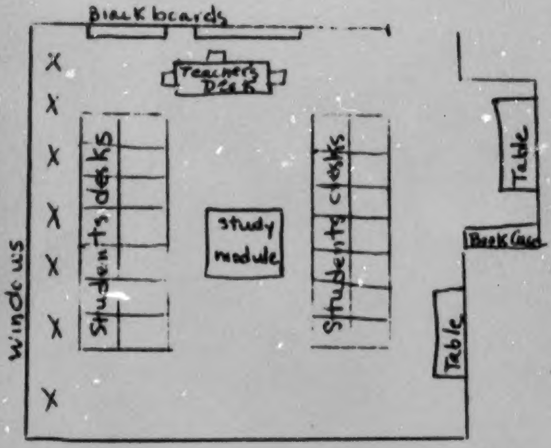


Scrounged knotty-pine paneling served as walls for the unbraced sides of the structure. Over the braced sides, the children hung curtains. The custodian cut out the plywood floor for us. The floor measurements of our structure turned out to be 48 inches x 49 inches instead of the planned 48 inches x 48 inches.

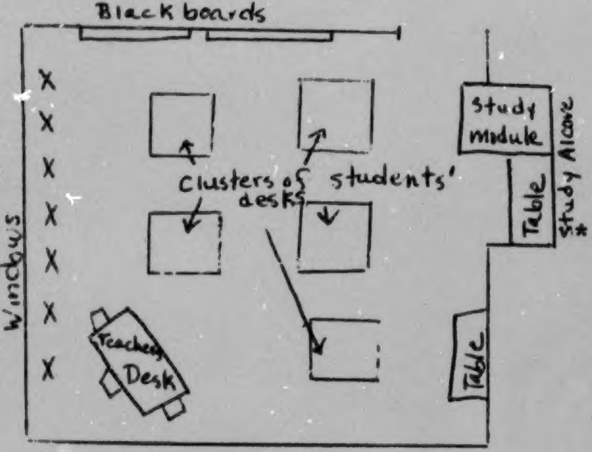
After putting down the floors, the students laid square pieces of carpet (4'x4') on the rough plywood floors and secured this covering with a staple gun. A desk was placed on the second story of the module. Two large pillows, placed on the bottom level, accommodated students who wanted to rest or read.

Once they completed their study module, the children discussed where in the alcove they should place it. They wanted a place that would maximize efficiency and convenience. The children quickly sketched some floor plans and rearranged the room.

Before



After



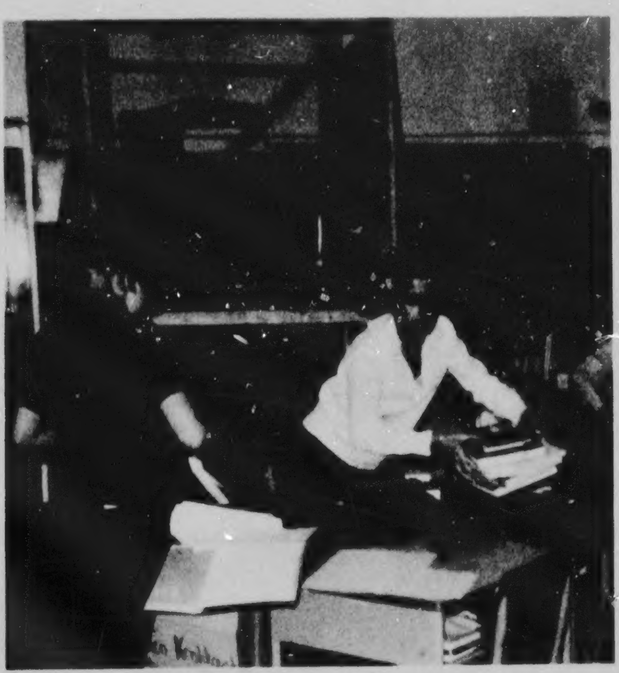
The class used the remaining wood to build two additional modules for the study area. The construction time for these was much less than for the prototype.

A forty-minute discussion that took place mid-way through our work on the Classroom Design challenge provided interesting feedback from the children. I asked them, "Why do you like or not like USMES?" and "What did you learn by doing this?" The children's responses included:

- it gives us an experience; teaches you a lot; we learned how to do something because we needed to know how; everybody learns how--not just a few people; we learned something we might use when we get big and get a job like this.

- working on wood isn't so hard; thought we'd only talk about it and then forget it...now I know we'll do it.

As the children worked on the Classroom Design challenge, I watched their confidence and self-image grow; each child felt a great pride of accomplishment. Also, their measuring skills improved greatly, according to the children's math teacher. The children assumed director roles; they organized themselves and assigned jobs without wasting time, effort, or talent. They shared duties and responsibilities in a way I had never before thought them able to.



3. LOG ON CLASSROOM DESIGN

by Bernard Walsh*
Hardy School, Grade 6
Arlington, Massachusetts
(September 1973-May 1974)

ABSTRACT

Although Mr. Walsh was not the regular teacher for this sixth-grade class, he worked almost daily with the children as they investigated ways to improve their classroom. Initial class discussions converged toward two issues: furniture and temperature. Many children wanted to sit at tables rather than desks. Children also complained that the high temperature in the room adversely affected their concentration. Moreover, students who sat near the heater, which was near a window, were either too hot or too cold. One group of children measured the temperature at various places in the room at thirty-minute intervals throughout several days, constantly refining their data-collecting skills in the process. Another group constructed a prototype kidney-shaped table in accordance with the preferences indicated by teachers and students in a survey. Several children proposed a new furniture arrangement after making trials on a scale model of the classroom that they had made. After examining and using the prototype table, the class revised the design slightly, and a group of students built two additional tables. The class established rules for proper behavior at the tables. While making further improvements in the room, the children learned that money had been allocated to the school to purchase a new type of flexible furniture for use in one teaching station. After much discussion the children agreed that another classroom probably needed such furniture more than they did. Six children observed a second-grade class and interviewed the teacher. They reported their findings to their classmates, who then made purchasing recommendations, most of which were followed. The class then became interested in improving management aspects of the classroom.

Work on the Classroom Design unit began with a discussion of the challenge: "How can we make this classroom a better place to live and learn?"*

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*Edited by USMES staff

After discussing what this challenge meant, the children became involved in a tallying exercise to determine how much time they spent in school and whether that amount of time comprised a major portion of their day. To determine this, the class selected one boy as the model and examined how he spent a typical weekday. Then the students looked at the amount of time he spent in school in one week. They determined that the boy spent close to thirty-one hours a week in school, and they felt that this was a large enough portion of his waking hours to warrant working on the challenge.

Various aspects of the room, such as color, furniture, and temperature, were discussed by the group. Of these topics, the class showed the most interest in altering the furniture and lowering the classroom temperature. The children also discussed problems in class management, including responsibilities of students and the role of the teacher. However, they decided that this topic was beyond their immediate concerns and agreed to postpone further investigation until a later date.**

During the first few sessions, each child described the physical characteristics of the classroom, and the class made a composite list from the descriptions. Many children commented that during their seven years at school they had sat at tables rather than desks only in kindergarten. However some children preferred desks and some preferred tables.

During the next session, we listed on the board pros and cons of desks:

Good Points About A Desk

1. Opens and shuts.
2. Has storage space.
3. Has a chair attached to it.
4. Provides each person with his own place.
5. Space doesn't have to be shared.

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*This is one possible wording of the challenge. Another way of stating the challenge may be decided upon as children discuss reasons for changing the classroom.--ED.

**If this is the overriding concern of a class, work might start immediately on the USMES unit, Classroom Management. --ED.

Problems With A Desk

1. Makes it hard for teacher to work in small groups.
2. The desk can't be moved closer because of attached chair.
3. Presents a problem during art: papers slip off.

Similar lists for tables were not compiled because the children had not had much experience with tables. To compensate for this, the entire class went on a tour of the building to observe three types of rooms: (1) those with desks only, (2) those with tables only, and (3) those with both.

Most of the classrooms that used only tables were primary-grade rooms, the class observed. Children then ventured again to various rooms to examine closely the different types of arrangement. They noted that (1) the need for private storage space for individual children was met in ways other than desks, e.g., painted ice-cream containers, and (2) classes that made greater use of tables tended to have a more open structure.

Back in their own room, the children discussed their observations. The children wanted to design a table that would meet their needs and be practical to use. Several sketches were put on the board for the class to examine.

Several children turned the attention of the class to the overheating problem. Very interested in this issue, the class decided to concentrate on it at the next session, while postponing further work on furniture design.

Those children who sat in front of the heater were more uncomfortable than those near the door. According to one child, the combination of draft from the window and heat from the heater resulted in constant discomfort. Agreeing that this was a problem, the children felt they could remedy the situation by changing the furniture arrangement to ensure that students would not be subjected to both draft and excessive heat. Some students remarked that the overly warm room caused them to (1) become sleepy, (2) get into trouble with the teacher, and (3) daydream.

Temperature varied from one place in the room to another, the class noted during a discussion at the next session. To verify this variation, the students decided to make temperature measurements under controlled circumstances. They chose five children to bring in thermometers and to measure five parts of the room several times during the day. These five data collectors were supposed to keep a record of their observations as well as their measurements.

Two students brought in thermometers the next day, and that afternoon they wrote on the board the measurements and observations they had made during the day.

Paula		Danny		
9:45	75°	10:25	73°	(2 windows open and lights off)
11:10	76°	11:30	76°	(1 window open and lights off)
12:15	75°	1:00	75°	(3 windows open and lights on)
12:52	73°	1:30	75°	(3 windows open and lights on)
1:30	78°			

Examination of the data focused on consistency. The class noted that (1) the two students did not measure the temperature at the same times and (2) only one of the pair made observations of room conditions (windows and lights). We needed to set up a plan to ensure that future sets of data would be comparable, the class decided. In addition, several students questioned the accuracy of the thermometers.

The class established four ground rules to ensure that future sets of data would be comparable and valid:

1. Temperature would be measured at predetermined times.
2. All factors affecting temperature would be considered, including the seven windows and two doors in the room.
3. Those making the measurements would keep an ongoing log of their observations.
4. Thermometers that give the same reading would be used.

Two children measured the room temperature during the next day and then presented the following data to the class:

9:00 A.M. - 77° - 2 windows open behind teacher's desk.

9:30 A.M. - 78° - 3 windows open, 1 window wide open, 1 door opened, lights off.

10:00 A.M. - 78° - 3 windows near teacher's desk open, 1 door open, lights off, heater on.

10:00 A.M. - 78° - 3 windows near teacher's desk open, 1 door open, lights off, heater on.

10:30 A.M. - 78° - 2 windows open, door closed, lights on, heater on.

11:00 A.M. - 78° - 2 windows open (end of room), doors closed, lights on, heater on.

11:30 A.M. - 78° - 3 windows open (very end of room), doors closed, heater on.

12:00 P.M. - 78° - 3 windows open (first one near teacher open a crack), doors closed, lights on, heater on.

1:00 P.M. - 76° - 1st, 5th, 6th window open, 1 door open, lights on, heater off.

1:30 P.M. - 76° - 4 windows open (1st, 5th, 6th open wide), 1 door open, lights on, heater off.

2:00 P.M. - 74° - 1 window open a crack and other windows wide open, both doors open, lights on, heater off.

Discussion of the data raised several questions:

1. What effect did the doors being open have on other classes?

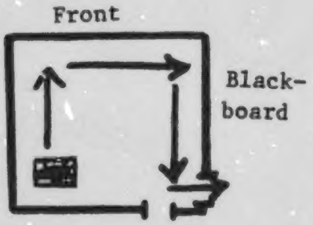
2. Where were the thermometers located when the temperatures were read and recorded?

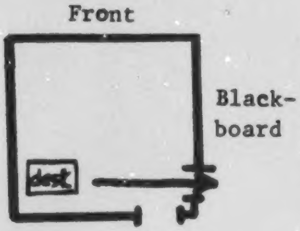
3. What can be said about the data collected?

The children tried to explain why the temperature dropped after lunch. One child pointed out that the windows were open more in the afternoon, but this reason was disputed by the class. Another child felt that the weather conditions outside the school affected the room temperature; the class then agreed to keep records of such conditions during future data collection. Someone remarked that the heat was turned off in the afternoon and this occurrence could account for the cooling trend.

Sections of the room near the heater seemed to be the warmest, noted some children near the heater. The class agreed to take this phenomenon into account when planning a new furniture arrangement.

I asked the students whether we could arrange the furniture in a way that would make them more comfortable and would afford them a safe exit in the case of an emergency. (This safety issue had arisen during an earlier discussion. Also at the beginning of the term the teacher had established rules for exiting: girls to the front of the room, boys to the rear.) The children wanted to know whether the present furniture arrangement allowed the quickest possible exit. They measured the distance that a student would travel in exiting if (1) the child followed the rules and (2) he or she went directly to the door. The students also timed individual children leaving the room via direct and indirect routes.





Exit Distance

1. Distance from student's desk to front row of room - 14'
2. Distance of front row to blackboard - 8'
3. Distance up the side aisle to door and out - 14'
4. Distance straight from student's desk to door with aisle desks removed - 21'

Exit Time

1. Seconds to go down aisle, across front, up aisle
   Run 1 - 18 seconds   Run 2 - 17 seconds

2. Seconds to go across room directly to door with desks removed
   Run 1 - 5 seconds   Run 2 - 4½ seconds

The children inferred from the data that the present arrangement and policy provided neither the fastest nor the safest route. According to the children's calculations, a direct exit took thirteen seconds less and was fifteen feet shorter than the indirect route.*

We formed two groups to investigate our two major concerns--temperature and furniture arrangement. The groups worked simultaneously; sometimes involving other classmates in their activities. Often the class worked as a whole.

The Temperature Group decided (1) to see which of the nine available thermometers could give identical readings in the same situations, (2) to find a control area in the school where nine thermometers could be tested, and (3) to find a way to represent on a comparison chart the temperature data for different locations in the classroom.

The group tested the thermometers in a refrigerator. Marked with the letters A through I, the instruments were left in the refrigerator for thirty minutes before being read. Only two gave the same reading. A discussion prompted by the discrepancies revealed that the children had placed the thermometers in different parts of the refrigerator, some were placed in the top near the freezer, others on the bottom. The children decided the thermometers should be placed as close together as possible and left for the entire weekend.

After the weekend, a few children recorded the temperature readings of the nine thermometers and reported to the class. The five thermometers giving the closest temperature readings were then used to measure the temperature in five different parts of the room.** Each member of the Tempera-

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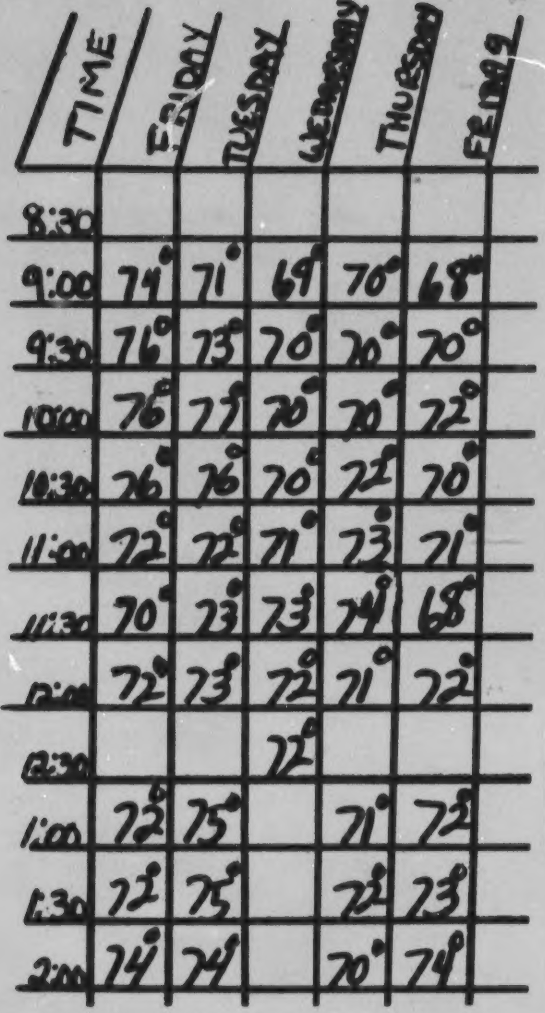
*The children might investigate the time needed to get from all possible locations to the door. A system might then be worked out to minimize the time needed for all students to exit from the room.--ED.

**The children might consider calibrating the discrepant thermometers. In addition to the refrigerator measurements, the students could take readings in a warm place in the room. If, in these two tests, some of the thermometers read consistently lower or higher than the accepted ones, simple correction charts could be devised.--ED.

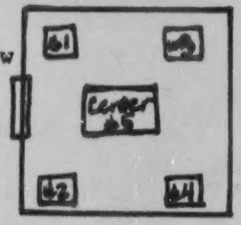


TIME	FRIDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
8:30					
9:00	74°	71°	69°	70°	68°
9:30	76°	73°	70°	70°	70°
10:00	76°	77°	70°	70°	72°
10:30	76°	76°	70°	72°	70°
11:00	72°	72°	71°	73°	71°
11:30	70°	73°	73°	74°	68°
12:00	72°	73°	72°	71°	72°
12:30			72°		
1:00	72°	75°		71°	72°
1:30	72°	75°		72°	73°
2:00	74°	74°		70°	74°

Figure C3-1

ture Group read one thermometer every half hour (except during lunch) over a five-day period. Each child sat near the thermometer he or she monitored. The thermometer locations were (as shown below) right front, right rear, left front, left rear and center.

Sketch of Room with Thermometer Locations Marked

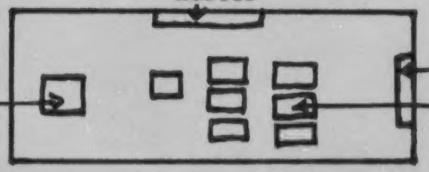


Still another student recorded the outside temperature at half-hour intervals for the same period using two thermometers. The children requested that their classroom teacher--

1. see whether other children who used the room could assist in the experiment,
2. leave instructions for children who used the room during the weekends not to remove the thermometers, and
3. help children get into the habit of recording the data.

Throughout the measuring period the children recorded their data on mimeographed forms (see Figure C3-1) and plotted the information on a pegboard graph. (To become familiar with graphs, the children played the game "Battleship.")

After the week of data collection, we discussed ways to represent the information. The children suggested making graphs, either individually or as a group, and finally decided to work in groups on this activity. One student became interested in mapping the temperature data onto a floor plan of the room to take into consideration the heating problem. (A sketch of his drawing is shown below.)



Graphing activities continued for several sessions. With some assistance, the children also calculated the average temperature over the five-day period for each area of the room.

The class discussed the completed graphs (see Figure C3-2 for an example). Although many students felt that we should verify the accuracy of the outside readings, they thought that we had to depend on the accuracy of the indoor readings because there was no way to check them.* I asked the children to think of sources for finding the outside temperature for October 24, 25, and 26. Their responses included (1) the Weather Bureau, (2) radio and TV stations, and (3) the airport.

Given a week to check as many sources as possible to verify their outside temperature data, the children had their information within a few days. One child obtained the temperature readings for the Arlington area on October 24 by contacting the New Bedford Weather Bureau. Upon examining his data, the children saw only one problem: the Weather Bureau readings were made on the hour whereas ours were made on the half hour. Another student had checked the weather report in the *Boston Globe,* but the class decided that the New Bedford information was more complete and should be used.**

The children observed that the 9:00 A.M. reading from the bureau showed a 4° difference from their own. They suggested and discussed possible reasons for the discrepancy:

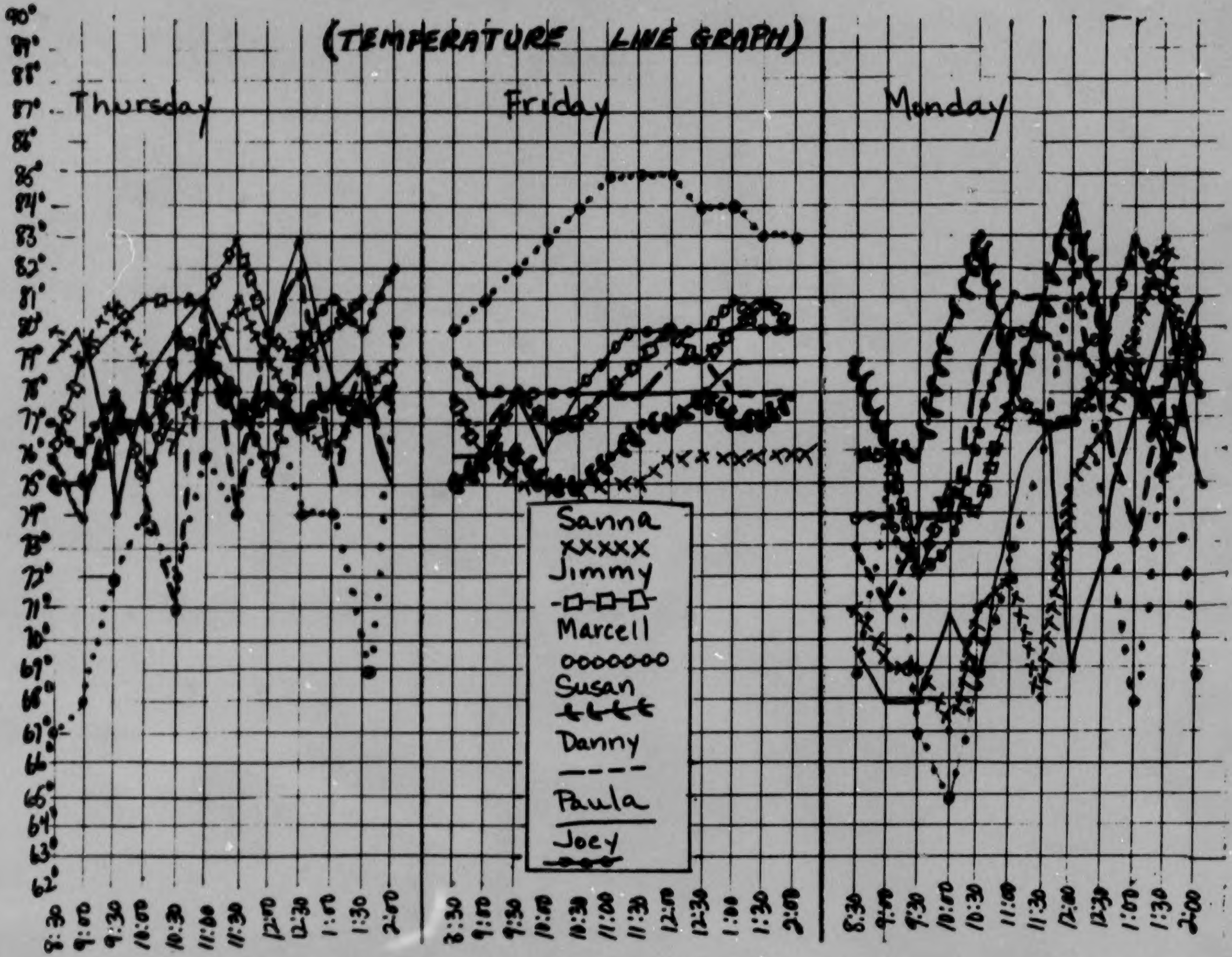
1. the different sites where readings were taken, and

2. the possible influence of the sun and wind on the thermometers.

---

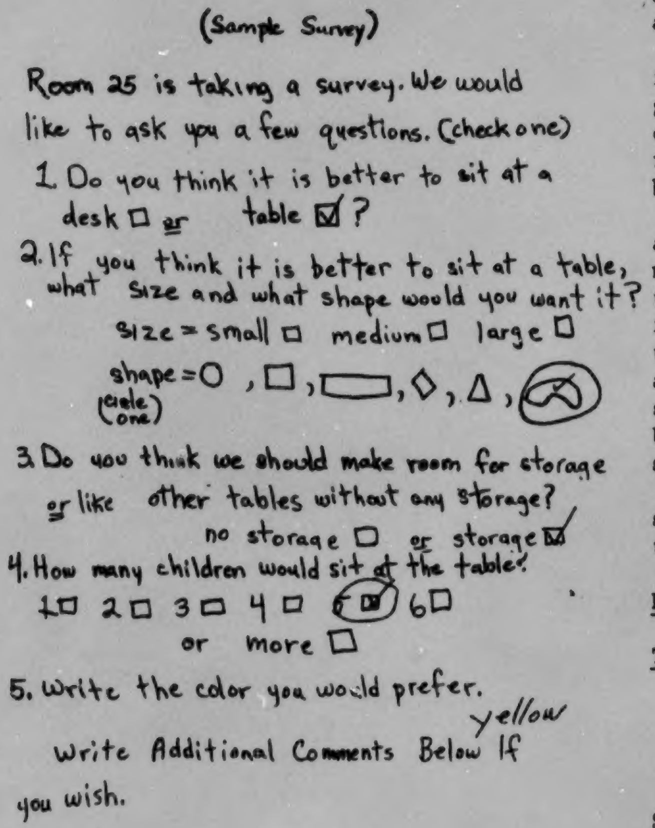
*They might borrow a lab thermometer from a high school science lab to check their readings. Also, a thermometer immersed in a mixture of ice and water should read 32°F, which provides at least a check on the accuracy of the thermometer.--ED.

**The children might discuss possible variations between the temperature given for the Arlington area and the more specific temperature outside their classroom. They might also discuss how a regional temperature might be determined and whether their own reading might be more accurate for a very specific location.--ED.


(TEMPERATURE LINE GRAPH)
Thursday
Friday
Monday
Sanna
xxxxx
Jimmy
-□-□-□-
Marcell
0000000
Susan
Danny

Paula
Joey
90°
89°
88°
87°
86°
85°
84°
83°
82°
81°
80°
79°
78°
77°
76°
75°
74°
73°
72°
71°
70°
69°
68°
67°
66°
65°
64°
63°
62°
8:30
9:00
9:30
10:00
10:30
11:00
11:30
12:00
12:30
1:00
1:30
2:00

Figure C3-2



(Sample Survey)

Room 25 is taking a survey. We would like to ask you a few questions. (check one)

1. Do you think it is better to sit at a desk ☐ or table ☑?

2. If you think it is better to sit at a table, what size and what shape would you want it?

size = small ☐ medium ☐ large ☐

shape = ○ , ☐ , ▭ , ◇ , △ ,
(circle one)

3. Do you think we should make room for storage or like other tables without any storage?

no storage ☐ or storage ☑

4. How many children would sit at the table?

1☐ 2☐ 3☐ 4☐ 5☒ 6☐ or more ☐

5. Write the color you would prefer. yellow

Write Additional Comments Below If you wish.

Figure C3-3

Based on all the data they had collected, the children concluded that we could control the temperature in the room by opening the windows and doors for certain periods of time and by moving desks away from the heaters.

The Temperature Group decided to postpone rearranging the furniture until the tables (under construction by the other group) were finished. In the meantime, they joined other classmates to make a posterboard scale model of the classroom and furniture. (Measurements of the room already had been taken.)

To determine how teachers in the school felt about desks and tables, some students suggested taking a survey. A committee of four drafted a set of questions which the class then reviewed and refined. (Figure C3-3 shows a copy of the final survey form.) One question asked people to select their preferred table shape. Included among the choices was a sketch of a kidney-shaped table. Several rooms in the school contained such tables (which had been built at the USMES 1973 National Workshop). The children distributed the survey to teachers in the school.

Out of the twenty-one teachers surveyed, thirteen responded. The Survey Group tallied the results and shared their information with the class.

Responses From Teachers

Table Preference	11	teachers preferred tables
	1	teacher preferred desks
	1	teacher said it depended on what the children were doing
Shape	9	kidney-shaped
	2	round
	1	square
	1	rectangular
	0	diamond
	0	triangular
Size	10	teachers preferred medium table
	1	teacher preferred smaller table
	1	teacher preferred larger table

Storage	9 teachers preferred table with a storage area 3 teachers preferred table without a storage area
Number of Children at Table	4 teachers wanted 3 children 3 teachers wanted 4 children 3 teachers wanted 5 children 2 teachers wanted 6 children 2 teachers wanted more than 6 children
Color Preference	6 teachers wanted blue or other pastel 5 teachers wanted yellow 1 had no preference

Group members regretted that they hadn't asked for the teacher's name: they felt it was important to know the grade level of each teacher who responded. They agreed that any future surveys would include a space for the teacher's name.

The class concluded that most teachers preferred tables to desks. We discussed the possibility that there might be some people who would want to sit at a desk while the others sat at tables.*

At a later class session, the children began to plan the construction of their table. A tally was taken on whether children in the class preferred to sit at a table or a desk. Six children chose to remain at their desks and three said they didn't care. The students compiled a list of things they had to do to build one table (e.g., painting, cutting, measuring, taping). Then they discussed how the work should be divided.

Using the measurements they had taken of available space in the classroom, a group of children determined the size of the table. The students figured out that twenty-five children would have to be accommodated at tables. One boy made a model, not to scale, of the kidney-shaped table. The size of the table was determined by the size of available Tri-Wall (4' x 6') and the size of the table constructed at the USMES National Workshop. He explained the model to the class. It was approved and construction began. The Tri-Wall was measured and the table top was drawn and cut.

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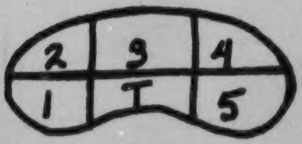
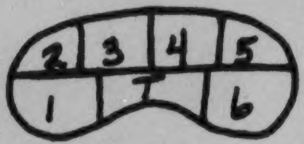
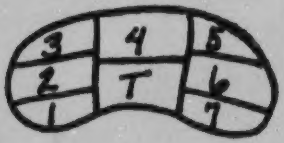
*The children might make bar graphs of the results of their survey of teacher preferences and then survey a sample of students to determine their preferences. Slope diagrams could be constructed to compare the fractions involved. See Background Papers on sampling techniques and on comparing fractions and ratios.--ED.

A group of children examined the table top to determine whether it could be used as the pattern for the other tables. They decided that the edges had to be more rounded.

The children tested the top for size and shape by using a desk as the base; they asked the classroom teacher to join their discussion. To determine how many children could sit at the table, they asked students to participate in trials. They tried five children plus a teacher, then six children plus a teacher, and finally seven children plus a teacher. A rough sketch of positioning and available storage space was made after each trial (see sketch below).







Students noted that a larger number of children per table meant fewer tables, and therefore, less materials. The class decided to complete the table for eight (seven children, one teacher) with storage space. The children would build more if they were satisfied with the results.*

Several children changed their minds and chose to sit at desks, thus reducing the required number of tables to three. Throughout the construction activities, groups of children visited other rooms to observe various table bases and cubby arrangements.

The group of children involved in the construction of the first table spent many class sessions in the Design Lab. (During this time, the Scale Model Group met in the classroom.) The table design called for several layers and a base. The children had difficulty putting the table top and reinforcement layer together because the Tri-Wall was warped in the center. After experimenting with hot glue and tape separately, they opted for a combination of both materials. A level, placed on the top, indicated success. Small sectional supports placed in each corner of the storage area strengthened the table. (See sketch of student's drawing below.)

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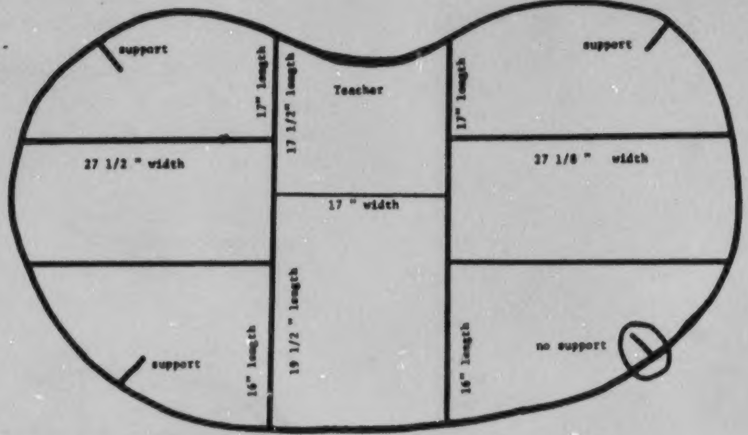
*The children might investigate the amount of table space needed by each child for both storage and working.--ED.



During the next class session, the children prepared a base for their table. Before cutting the Tri-Wall, the children determined the best height for the table. They had planned to measure the heights of their classmates but discovered through discussion and observation that leg length was more important than height.* Some children in the group suggested using as a guide the round table (twenty-nine inches high) already in the room.

A group of children measured the two cylinders that were to be used for the base. Several students took turns cutting the cylinders.

When the finished table was brought to the class, the children noticed that an error in measuring the base had re-

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*The children might collect data on the different measurements used in determining a comfortable height, e.g., distance from top of thigh to floor and most comfortable height for writing. They might also design a small adjustable table to use as a measuring instrument. The children can draw histograms of the data and analyze them to determine the best table height. See Designing for Human Proportions unit.--ED.

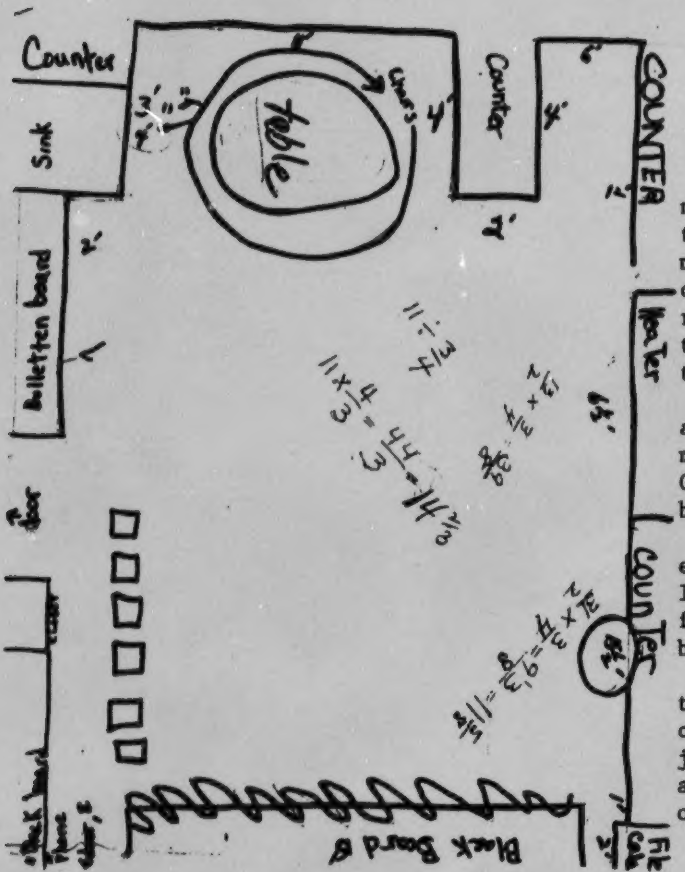
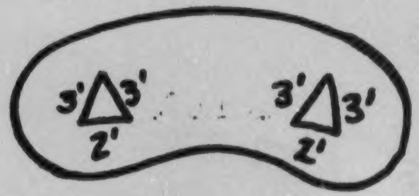


Figure C3-4

sulted in a table height of only twenty-two inches--too low for the children's legs. The builders returned to the Design Lab to come up with another base.

There were no other cylinders available; the children had to make a Tri-Wall base that would use a minimum amount of Tri-Wall. We tried to design a triangular support on paper. The children decided that the table top needed one support on each end (see sketch below).



Meanwhile, the Scale Model Group constructed a scale model of the classroom out of posterboard, working with the teacher and the "How To" Cards. The room was measured, re-measured, and sketched (see Figure C3-4). The group decided on the scale of 3/4 inch of poster board to one foot of the room. The children experienced some difficulty in reading their rulers while measuring the room and in reducing fractions to convert the measurement to their scale.*

Using the scale model, the children tried to anticipate and solve problems that might arise from furniture arrangement. Following the recommendations of the Temperature Group, they decided to place all tables away from heating blowers and doors.

The children viewed the original placement of the teacher's desk at the back of the room as an indication of her lack of trust in them. They agreed with many of her reasons for the desk placement, including the privacy it afforded, but felt that it separated her from the group.

The group presented the completed scale model of furniture and room to the class. The children discovered and discussed several errors in the model furniture. Classmates joined in making scale models of the chairs to be placed around the tables; they felt that this was the only way to obtain an accurate picture of the room.

While working on these model seats, they spotted and corrected another error. In calculating the dimensions of the posterboard classroom model, the children had 3/4 inch of posterboard equal to one inch of the room instead of one foot of the room. The entire class was involved in mathematical computations and measurement activities while making and checking the scale model.

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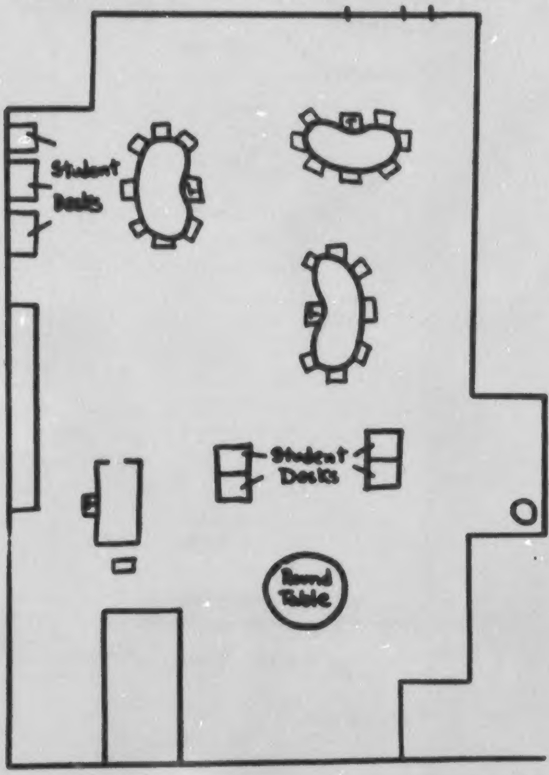
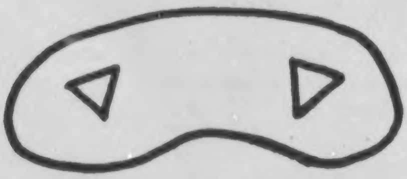
*The children might also consider making a conversion graph and might consult "How To" Cards on this activity.--ED.

During the next session, the class discussed furniture arrangement, particularly regarding fire regulations and the overheating problem. Arrangements were made for those children who chose to remain at their desks. In addition, all felt that children sitting at tables should be allowed to change back to a desk if they wished (assuming they first discussed the matter with the teacher). Also, the children acknowledged that they would have to take a lot of responsibility for the cleaning of the room. The Scale Model Group met with the teacher during the next session to complete the model. The children exhibited a great deal of patience during the many sessions spent discussing and revising their model. (See sketch below of final model.)



After considering the prototype table, the class agreed on three modifications for the tables that would soon undergo construction: (1) tables should be the same height (29") but should have six inches of storage space instead of seven to provide another inch of leg room, (2) different chairs should be used, and (3) varnish should be applied to the surfaces.

Triangular bases constructed by the children had one side one inch longer than the other sides to allow for overlap. After we taped the bases together, several children and I tried them out with the table top. The children wanted to find the placement of the bases that would allow the most leg room.* They decided on the configuration sketched below.



After gluing the bases to the top, we noticed a slight wobble. The children resanded one base and used tape to build up its edges. Using a level, they determined that the floor in their room was not perfectly horizontal and cited this as the reason for the wobble.

The tables became steadier as they aged; books were added to the storage area to weigh it down. The children covered the storage compartments with contact paper to help preserve the table.

I asked the children seated at one of the tables to keep a log of their reactions to sitting at the table and of what takes place at the table. Other students wrote down their observations of the children who kept logs.

Students exchanged observations during the next session. They enjoyed sitting at the table; they were more comfortable even though table space was limited at times when the children had books on the table.

The furniture in the room was arranged according to the scale model of the classroom constructed by the children.

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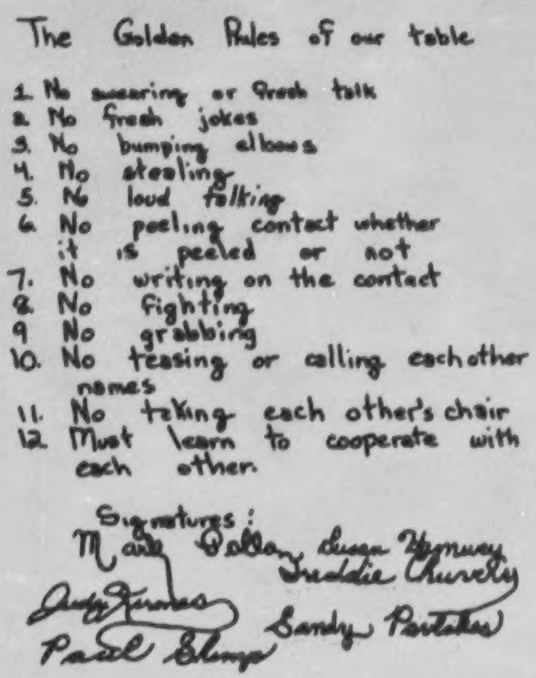
*The children might also investigate the amount of weight that could be placed on the edge of the table when the bases were different distances from the edge.--ED.

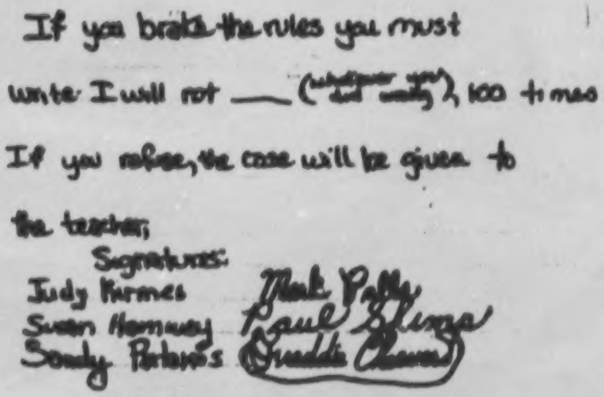


The Golden Rules of our table

1. No swearing or fresh talk
2. No fresh jokes
3. No bumping elbows
4. No stealing
5. No loud talking
6. No peeling contact whether it is peeled or not
7. No writing on the contact
8. No fighting
9 No grabbing
10. No teasing or calling each other names
11. No taking each other's chair
12. Must learn to cooperate with each other.

Signatures:
Mark Palla Susan Hemway
Freddie Chavez
Judy Karnes Sandy Partanos
Paul Slimp

Figure C3-5



If you brake the rules you must
write I will not ___ (whatever you did wrong), 100 times
If you refuse, the case will be given to
the teacher,
Signatures:
Judy Karnes Mark Palla
Susan Hemway Paul Slimp
Sandy Partanos Freddie Chavez

Figure C3-6

The new arrangement posed problems: some of the desks and tables blocked the aisles. In accordance with fire regulations, we had to change the arrangement to allow for quick exit from the room and easy access to the phone and storage areas. We shifted the table locations, and some of the children who remained at their desks changed their positions.

Officials from the Fire Department inspected our school at the end of March. They ordered the tables removed because the Tri-Wall structures did not meet fire regulations. Upset by this, the children reviewed the regulations to see what they could do to save the tables. They discovered that the tables would meet fire regulations if painted with fire retardant paint and if the edges were sealed with duct tape. The children each chipped in twenty-five cents to pay for the materials. Everyone was very relieved.

We spent a great deal of time talking about the need for more effective organization. The children discussed the importance of working cooperatively within a small group and listed the following common rules of acceptable behavior at the tables:

1. No fooling around.
2. No fighting.
3. No loud talking.
4. Share, but don't take without permission.
5. Allow room for other children.
6. Be able to discipline ourselves sometimes without the teacher.
7. To have a child moved, all would have to agree.
8. Anyone could move from the table after a discussion with the teacher and the other children at the table.

All agreed that the important factor was teamwork. The children at Table III drafted a set of rules and signed them (see Figure C3-5). They also drew up guidelines to be followed when and if the rules were broken (see Figure C3-6).

Amid two new activities, planning bulletin board displays and building an "idea" box for the room, an unexpected development occurred. Fifteen hundred dollars were allocated to our school for the purpose of purchasing a new type of adjustable furniture to be used in one classroom. I asked the children how they felt about their present classroom furniture, including the tables they had constructed. Although they liked it, they noted some problems: (1) tables needed additional supports, (2) shape of storage areas in tables was limiting, and (3) table top area was limited, particularly while children worked on subjects involving many books.

Furniture catalogues were distributed and I asked the students to be ready to discuss their impressions of this new furniture. The children suggested ways the different types of furniture could be used. Many of the modules, including study carrels, tables, dividers, and tote trays, were shown on an opaque projector. The children especially liked the bright colors of the furniture.

During later sessions, the children, their teacher, and I again discussed the new furniture and raised some questions: Would everyone have to sit at tables? Could the $1500 worth of furniture be distributed to two rooms? I explained that we would have to use more than just new tables. The children agreed to draw a floor plan of the room to see how much furniture the room could accommodate.

After much discussion and thought, the teacher and I decided that the new furniture was intended to provide maximum flexibility and storage space in a room. She and I agreed that the furniture would be wasted in her room, which already had a great deal of storage space. I decided to bring the problem to the children's attention. Together, we reviewed the catalogue, particularly the descriptions and specifications of the furniture. I asked the class to think about other rooms in the school where the furniture might be needed more. We considered the following items:

1. Setting up priorities in the room. (Should the money be spent on tables when tables had just been constructed?....on tote trays, when storage space at tables exists?)

2. Existing storage space in their room. (Where in the school is there the greatest need for storage?)

3. Cost factor.

The children agreed to go to another classroom in the school and apply the three considerations to that room as well as to their own room. A group accompanied me to a second-grade open classroom containing borrowed and scrounged furniture. They observed the room, talked with the teacher, took some measurements, and prepared an oral report for the rest of their class. The observation was a valuable experience for the children.

The second-grade teacher was asked to identify some of the problems in her room and select catalogue items that would alleviate those problems. She pointed out that she did not have enough storage space, the homemade furniture was wearing out, and the Fire Department had ordered it removed. In addition, she explained to the children that the activities taking place in her classroom required much storage and display space.

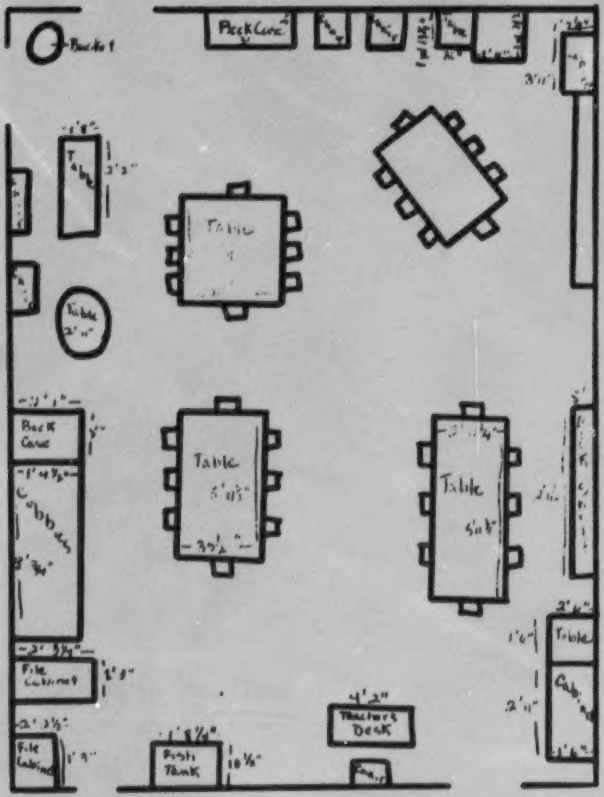
During the next session, the children reported their observations to their classmates. The observations supported the hypothesis that there was a greater need for the new furniture in the second-grade classroom. The observers placed the need for storage above the need for tables as criteria for selecting the new furniture. The children also discussed the possibility of spending a portion of the money in their own room. They decided that some stackable chairs should be purchased for their room so that the borrowed chairs could be returned. Keeping in mind the measurements of the second-grade room, the needs of the room, and the available furniture designs, the class drew up the following list of recommendations:

1. storage (at least 5 modules)
2. tables (at least 3 tables measuring 30" x 60"; present tables had to be returned
3. chairs (at least 15 stackable chairs for the reading circle)
4. totes (to replace homemade cubbies which were condemned by the Fire Department)

Before the new furniture was ordered, the class made sketches of the room. (See sketch of child's drawing on next page.)

The children totaled the costs of the proposed purchases for the two classrooms. This computation included calculating a 25% discount.

The teacher presented their ideas at a meeting with the second-grade teacher. She felt their presentation represented an accurate appraisal of the problems in her room. She added that she was considering other purchases, but these certainly didn't invalidate the recommendations. She wanted to order room-dividing panels to create interest areas and a quiet corner. A field trip was planned to enable the children to see this type of furniture in use at a nearby school. After the trip, the children agreed that the dividers were very useful and noted that they could be written on with chalk as well as with felt-tip marker, an ad-



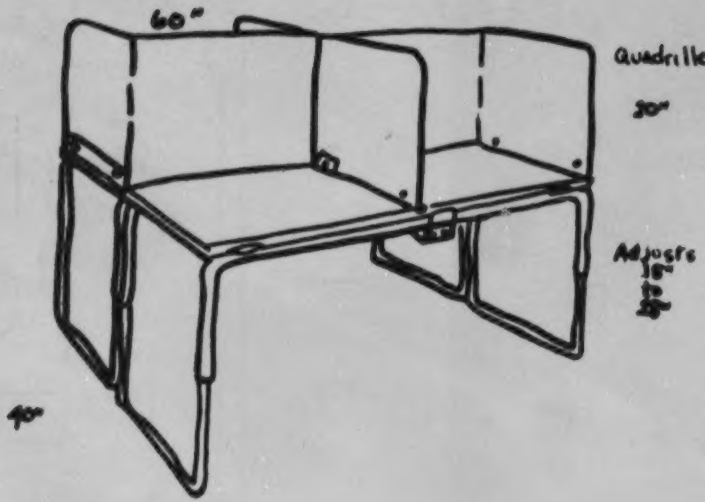
vantage enhanced by the paper shortage.

The purchase order, completed on the following Tuesday by me and the second-grade teacher, contained the following items:

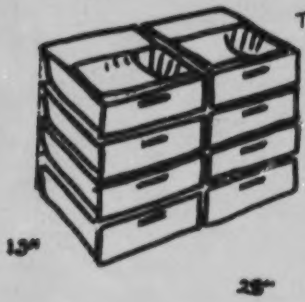
4 tote tray assemblies
1 paint station
1 mobile file
1 quadrille carrel
1 adjustable height table top
1 toy bin
1 two-sided container
4 metal shelves
1 clip

1 base pad
1 carrel
3 hangers
2 poles
2 panel kits
1 chalk/cork panel
1 laminate cork panel
2 table bases,
20" x 60" x 24"

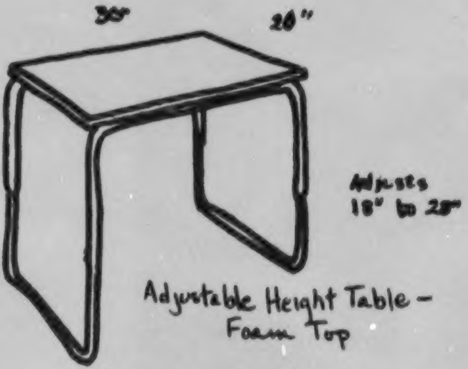
(Pictures of some of the selected items can be seen on the next page.)



Quadrille Carrel



Tote Tray Assembly



Adjustable Height Table -
Foam Top

Several class sessions were spent discussing classroom management and scheduling, including the roles of teacher and student. The children expressed a desire to have more voice in the decision-making process within the room. I explored with them various ways to effect change. They wanted to have a daily recess, and they made plans to present this request to the teacher. The children realized that they had to gather much information to substantiate their request.*

Throughout the children's involvement with the Classroom Design challenge, I saw an increase in their ability to work in group situations with a minimum of adult direction. Natural leaders developed within the groups and the children were able to organize themselves. Furthermore, these abilities carried over to non-USMES activities.

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*The children might want to decide on a challenge which pertains to problems of classroom management and scheduling and then start working on the various aspects of the problem. See USMES unit, Classroom Management.--ED.

4. LOG ON CLASSROOM DESIGN

by Robert Farias*
Adams School, Grade 6
Lexington, Massachusetts
(September 1973-March 1974)

ABSTRACT

Children in this sixth-grade class believed they would learn better in an improved classroom environment. Some students surveyed the class to find out about people's preferences concerning seating plans and furniture arrangement. The class drew proposed layouts and later in the semester rearranged furniture. To enhance the room's appearance, the children formed two groups: one to design and construct wastebaskets, the other to decorate the room. Two guidelines focused the work of the Wastebasket Group: (1) build a better basket that would encourage people to use it and (2) make the baskets suitable for use in other parts of the school as well as the classroom. After successively refining their designs and experimenting with circuits and switches, the children built a basket that incorporated a bulb that lighted whenever the basket cover was lifted. Three such baskets were placed on the school's playing field at locations determined by the children's previous observations of litter accumulation. Breakage problems resulting from overuse forced the children to relocate the baskets indoors. The Decoration Group painted the classroom bulletin boards blue, choosing the color by class vote. Members of the group surveyed the class about a variety of decorating issues. The children brightened the room with such additions as foot-shaped cutouts on the walls and contact paper on some tables. As the students began working on another USMES unit, Growing Plants, the children rearranged the furniture to accommodate the plants, basing some of their decisions on measurements of temperature in various parts of the room. The class also established a job and banking system to improve the operation of the classroom.

On the first Monday of school, my sixth graders discussed how they could make the classroom a better place to live and

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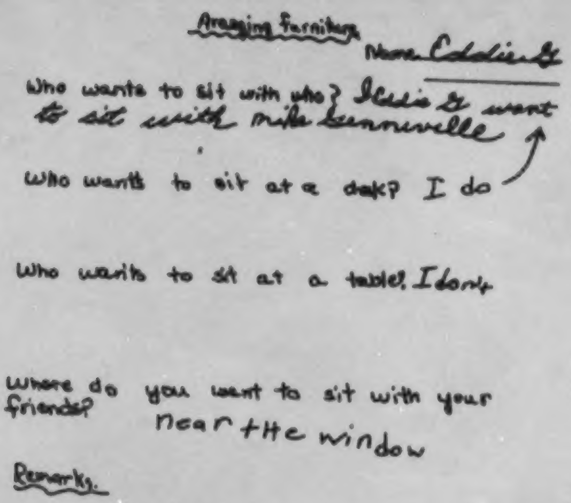
*Edited by USMES staff



Arranging furniture

Name Eddie G

Who wants to sit with who? Eddie G want to sit with mike Lennuville

Who wants to sit at a desk? I do

Who wants to sit at a table? I don't

Where do you want to sit with your friends? near the window

Remarks.

Figure C4-1

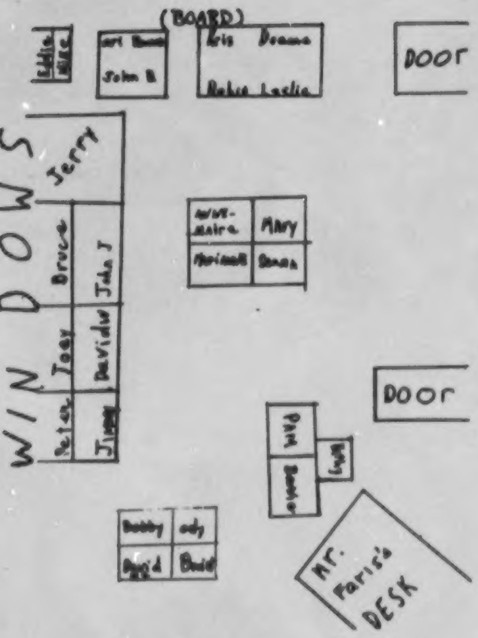


Figure C4-2

learn. The children felt that the room was too bare; they wanted to decorate it to make it more attractive. They believed that if their environment were improved, they would learn better and be happier. Furniture and room arrangement also interested the children. Each child wanted to pick a friend to sit next to. This became difficult because there were intersections of sets of pairs of friends; these intersections were discussed using Venn Diagrams.*

A group of students devised and conducted a seating-preference survey for the class (see figure C4-1) and tallied the results separately for boys and girls. The children's findings, including a copy of their survey, were presented to the class on the overhead projector. Based on the information collected, the class drew room plans (see Figure C4-2) and later made changes in the room arrangement.

Further class discussion helped the children focus on two areas for investigation: wastepaper baskets and decorations. The class formed two groups. The Wastebasket Group met regularly until construction activities were completed. Students on the Decoration Committee met throughout the year, often changing decorations as a result of new ideas.

Accumulation of clutter and dirt presented a major problem in our room whenever students worked on projects. I asked the children whether there was some way we could make a basket that would, by its design, encourage people to use it. Suggestions included baskets that would light when used properly and those that would make a noise. Some children wanted to construct wastebaskets not only for our classroom, but for other parts of the school as well. They realized that widespread use would warrant a design that would be adaptable to many situations. During the next three days, those children interested in the design and construction of wastebaskets made a series of preliminary sketches; each successive drawing included greater detail about color, size, and shape (see Figure C4-3).

During the next class session, the children designing electric wastebaskets were given batteries and bulbs. The group chose to use batteries as a power source rather than electrical outlets because batteries allowed the children to make the baskets portable and to eliminate the danger of electric shocks. The children diagrammed the methods they used to get their bulbs to light. Diagrams completed early in the session included only one or two wires. By the end of the session, the children were experimenting with switches to control their lights.

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*The children might also discuss how sitting at tables would allow them to be next to two friends.--ED.

I accompanied several children to the Design Lab, where they experimented with ways to make a circuit go on and off as the cover of a box opened and closed. Several groups formed to work on the problem. In response to my query about how the switches could be tested without a prototype basket, a few students offered to build a model of the wastebasket top they had designed. The children used cardboard, masking tape, thumbtacks, wires, and batteries. By the end of the session, the children had overcome a recurring short-circuit problem and had determined how to make the connections for the circuit. I mentioned to the children several items that warranted consideration before we returned to the room:

1. necessary wiring
2. how to make contact when the cover isn't lifted all the way
3. length of time the battery will last
4. durability of the system

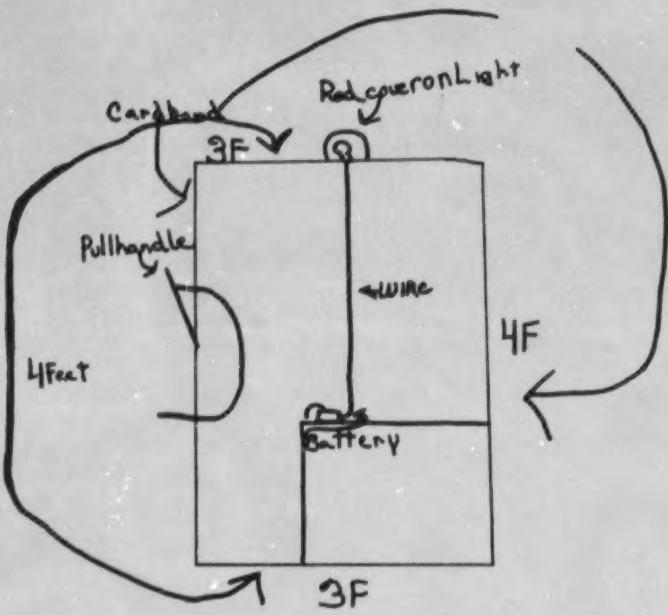


Figure C4-3

During the next class session the Wastebasket Group gave a progress report to the rest of the class. The description of one basket sparked a lengthy discussion. The basket was a large box with a pulley-operated flip top. When the box was opened, a bell rang and a bulb lighted. One child felt that schoolmates would keep pulling at the basket until it broke. A member of the Wastebasket Committee responded that the placement of the basket would be placed in the second-floor hall and used by fourth, fifth, and sixth graders. A poll of the class, however, showed that a majority disagreed with the group member's report.

The class decided to observe and experiment to determine how many baskets to make and where to place them. Six students, three in the school building and three on the playground, observed the accumulation of litter during snack recess. Other students continued their construction activities in the Design Lab.

Three days later, at the next class session, students reported on the proposed locations of the wastebaskets. The children used an overhead projector to show a diagram of the playing field with proposed basket locations marked at (1) the playground entrance closest to the cafeteria, (2) the area used most by students, and (3) the extreme right side of the field (see Figure C4-4). The proposed sites were based on observations of the playground made over a period of several days. The class discussed how the building position and the wind possibly accounted for litter accumulation in certain areas. Children noted that the wind usually blows from left to right across the field.

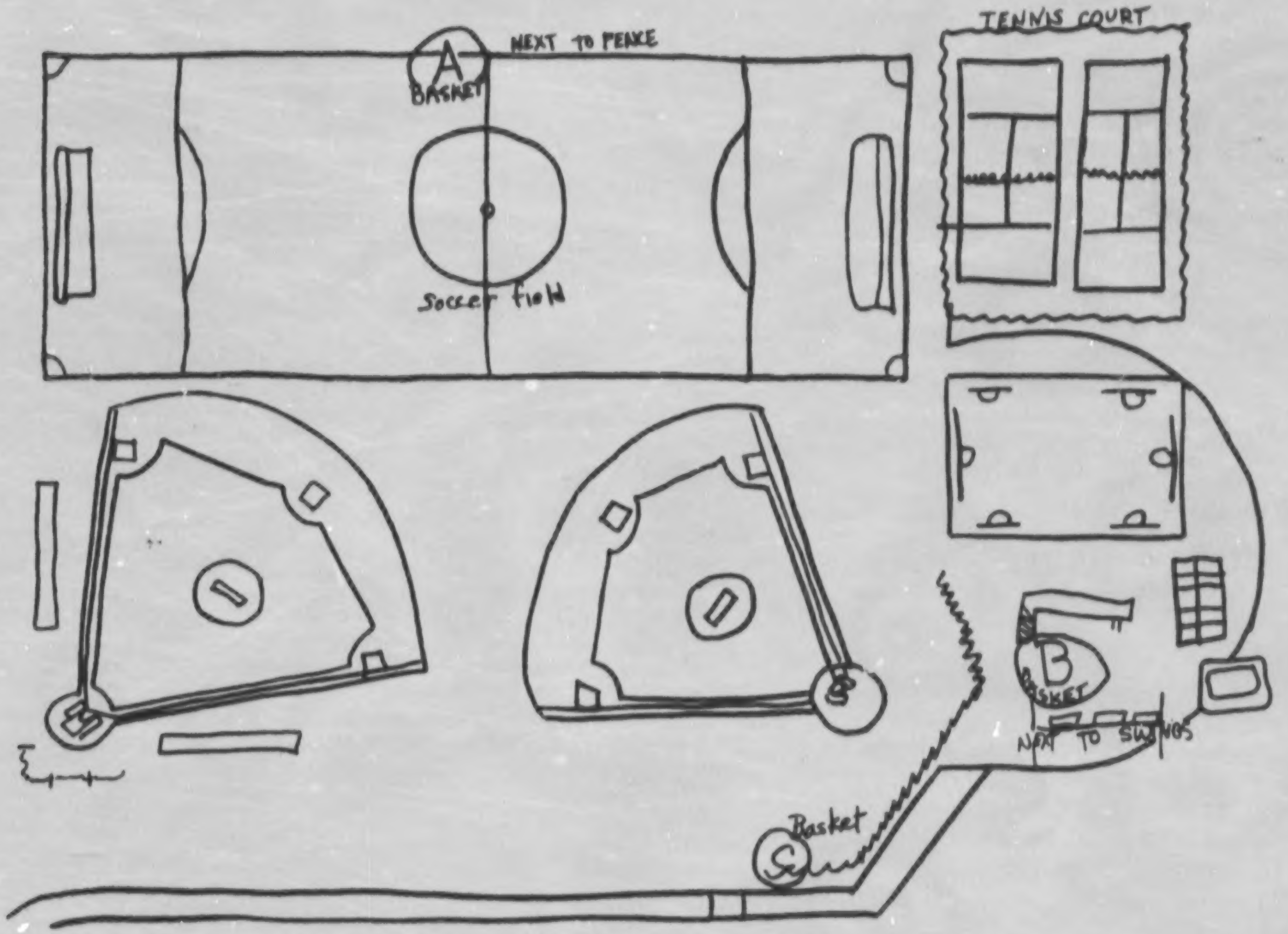
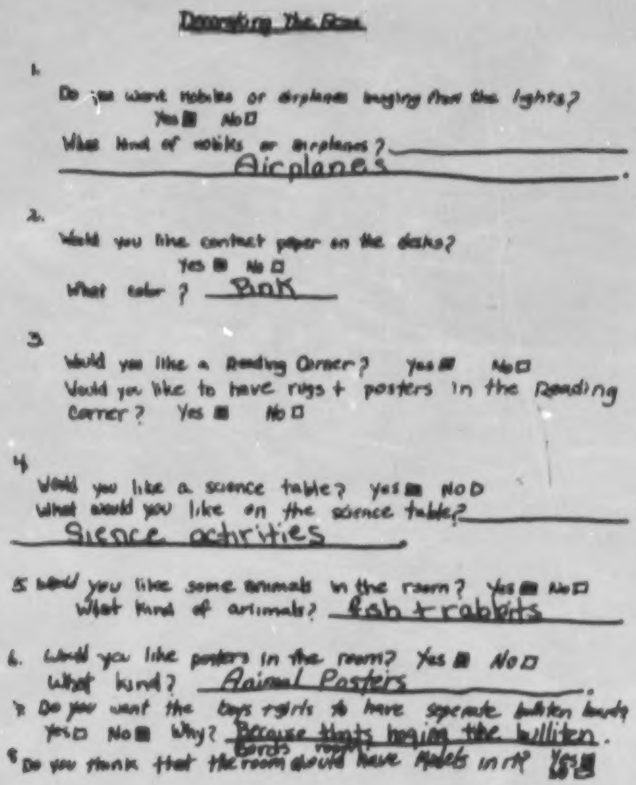


Figure C4-4



Decorating the Room

1\.
Do you want mobiles or airplanes hanging from the lights?
Yes ■ No ☐
What kind of mobiles or airplanes? Airplanes.

2\.
Would you like contact paper on the desks?
Yes ■ No ☐
What color? Pink

3\.
Would you like a Reading Corner? Yes ■ No ☐
Would you like to have rugs + posters in the Reading Corner? Yes ■ No ☐

4\.
Would you like a science table? Yes ■ No ☐
What would you like on the science table? Sience activities.

5 Would you like some animals in the room? Yes ■ No ☐
What kind of animals? fish + rabbits

6. Would you like posters in the room? Yes ■ No ☐
What kind? Animal Posters.

7 Do you want the boys + girls to have seperate bulliten boards
Yes ☐ No ■ Why? Because thats hoging the bulliten boards.

8 Do you think that the room should have Models in it? Yes ■ No ☐

Figure C4-5

Construction activities completed during the next several weeks included making signs for the baskets, painting the baskets, and assembling circuits based on information from the electricity "How To" Cards.

On the first day that the children placed the baskets outside, it rained. To prevent water damage to the Tri-Wall, the baskets had to be brought inside. The children placed them outside on the following morning. A check at the end of the day showed that the baskets were used a great deal. Younger children in the school enjoyed hearing the bell ring and seeing the light go on so much that the baskets were somewhat damaged.

My students discussed the breakage problem and decided to place the baskets indoors. A check after one day revealed that not much trash had been collected. After several days, the children decided that the baskets were not really needed inside the school. The class resolved to make more durable baskets for the following spring.

Meanwhile, the Decoration Group also had been hard at work. These children painted the bulletin boards blue with a yellow and red trim. A vote had shown that blue was the favorite color of a majority of students in the class.

Group members designed and conducted a survey to find out how classmates felt about a variety of decoration issues (see Figure C4-5). The committee brightened the room by attaching foot-shaped paper cutouts on the wall (walking towards the ceiling) and placing contact paper on some tables.

In accordance with the floor plans and the surveys developed earlier in the semester, the Decoration Group changed the room arrangement. My desk was moved to a different corner of the room, children's desks were clustered, and activity tables and a library corner were set up.

Later in the semester, as my students began working on another USMES unit, Growing Plants, the children once again changed the furniture arrangement to accommodate the plants. Temperature data was collected to help determine the best possible placement of the plants. The results indicated as much as a ten-degree difference between various parts of the room. Tables and bookcases were placed in the cooler parts of the room. The children placed their desks in the middle of the room, where the temperature was fairly constant.

Changing the physical characteristics of the classroom was not the only means of improvement that the children envisioned. They wanted to establish a job and banking system to improve the operation of the classroom.* Toward this end they carried out the following activities:

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*This topic would come up most naturally under Classroom Management.--ED.

1. discussing why such a system would be needed
2. establishing the importance of various jobs according to their potential for improving the classroom
3. conducting surveys to determine wages for jobs, value of play money, prices of supplies, and amount of allowances
4. establishing a system for selecting and changing jobs

The children's interest was sustained throughout our work on the Classroom Design challenge. Many were eager to improve other areas of the school, particularly the unused auditorium space. In retrospect, they felt that they had a strong voice in the creation of an environment that was conducive to learning.

D. References

1. LIST OF "HOW TO" CARDS

Below are listed the current "How To" Card titles that students working on the Classroom Design challenge might find useful. A complete listing of both the "How To" Cards and the Design Lab "How To" Cards is contained in the USMES Guide. In addition, the Design Lab Manual contains the list of Design Lab "How To" Cards.

ELECTRICITY	EC 1	How to Make Simple Electric Circuits
	EC 2	How to Check a Circuit by Tracing the Path of the Electricity
	EC 3	How to Make Good Electrical Connections
	EC 4	How to Find Out What Things to Use in an Electric Circuit
	EC 5	How to Make a Battery Holder and Bulb Socket
	EC 6	How to Make a Battery and Bulb Tester
	EC 7	How to Find Out Why a Circuit Does Not Work
	EC 8	How to Turn Things in Electric Circuits On and Off
	EC 9	How to Find Out Why a Bulb Sometimes Gets Dim or Goes Out When Another Battery is Added to the Circuit
	EC10	How to Connect Several Things to One Source of Electricity
	EC11	How to Draw Simple Pictures of Electric Circuits
	EC12	How to Use Electromagnets to Turn Things in Electric Circuits On and Off
GEOMETRY	G 3	How to Construct a Circle Which is a Certain Distance Around
GRAPHING	GR 1	How to Make a Bar Graph Picture of Your Data
	GR 2	How to Show the Differences in Many Measurements or Counts of the Same Thing by Making a Histogram
	GR 3	How to Make a Line Graph Picture of Your Data
	GR 4	How to Decide Whether to Make a Bar Graph Picture or a Line Graph Picture of Your Data
	GR 5	How to Find Out If There is Any Relationship Between Two Things by Making a Scatter Graph
	GR 6	How to Make Predictions by Using a Scatter Graph
	GR 7	How to Show Several Sets of Data on One Graph
MEASUREMENT	M 1	How to Use a Stopwatch
	M 2	How to Measure Distances
	M 3	How to Measure Large Distances by Using a Trundle Wheel

MEASUREMENT (cont.)	M 9	How to Make a Conversion Graph to Use in Changing Measurements from One Unit to Another Unit
	M 10	How to Use a Conversion Graph to Change *Any* Measurement in One Unit to Another Unit
PROBABILITY AND STATISTICS	PS 2	How to Record Data by Tallying
	PS 3	How to Describe Your Set of Data by Finding the Average
	PS 4	How to Describe Your Set of Data by Using the Middle Piece (Median)
	PS 5	How to Find the Median of a Set of Data from a Histogram
RATIOS, PROPORTIONS, AND SCALING	R 1	How to Compare Fractions or Ratios by Making a Triangle Diagram*
	R 2	How to Make a Drawing to Scale
	R 3	How to Make Scale Drawings Bigger or Smaller

New titles to be added in 1976:

How to Round Off Data
How to Design and Analyze a Survey
How to Design an Experiment
How to Make and Use a Cumulative Distribution Graph
How to Measure Light Intensity
How to Measure Sound Intensity

A cartoon-style set of "How To" Cards for primary grades is being developed from the present complete set. In most cases titles are different and contents have been rearranged among the various titles. It is planned that this additional set will be available early in 1977.

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*Presently called Slope Diagram.

2. LIST OF BACKGROUND PAPERS

As students work on USMES challenges, teachers may need background information that is not readily accessible elsewhere. The Background Papers fulfill this need and often include descriptions of activities and investigations that students might carry out.

Below are listed titles of current Background Papers that teachers may find pertinent to Classroom Design. The papers are grouped in the categories shown, but in some cases the categories overlap. For example, some papers about graphing also deal with probability and statistics.

The Background Papers are being revised, reorganized, and rewritten. As a result, many of the titles will change.

DESIGN PROBLEMS	*DP 4 Electromagnet Design* by Earle Lomon *DP13 People and Space* by Gorman Gilbert
ELECTRICITY	*EC 1 Basic Electric Circuits* (based on suggestions by Thacher Robinson) *EC 2 Trouble Shooting on Electric Circuits* (based on suggestions by Thacher Robinson)
GRAPHING	*GR 3 Using Graphs to Understand Data* by Earle Lomon *GR 4 Representing Several Sets of Data on One Graph* by Betty Beck *GR 6 Using Scatter Graphs to Spot Trends* by Earle Lomon *GR 7 Data Gathering and Generating Graphs at the Same Time (or Stack 'Em and Graph 'Em at One Fell Swoop!)* by Edward Liddle
GROUP DYNAMICS	*GD 2 A Voting Procedure Comparison That May Arise in USMES Activities* by Earle Lomon
MEASUREMENT	*M 3 Determining the Best Instrument to Use for a Certain Measurement* by USMES Staff *M 5 Electric Trundle Wheel* by Charles Donahoe

PROBABILITY AND STATISTICS	*PS 1 Collecting Data in Sets or Samples* by USMES Staff *PS 4 Design of Surveys and Samples* by Susan J. Devlin and Anne E. Freeny *PS 5 Examining One and Two Sets of Data Part I: A General Strategy and One-Sample Methods* by Lorraine Denby and James Landwehr
RATIOS, PROPORTIONS, AND SCALING	*R 1 Graphic Comparison of Fractions* by Merrill Goldberg *R 2 Geometric Comparison of Ratios* by Earle Lomon *R 3 Making and Using a Scale Drawing* by Earle Lomon
SIMULATION ACTIVITIES	*SA 1 The Sit-Down Game* by Merrill Goldberg *SA 2 Set Theory Activities: Rope Circles and Venn Diagrams* by Merrill Goldberg

3. BIBLIOGRAPHY OF NON-USMES MATERIALS

The following materials are references that may be of some use during work on Classroom Design. The teacher is advised to check directly with the publisher regarding current prices. A list of references on general mathematics and science topics can be found in the *USMES Guide*.

Books for Teachers

Biggs, Edith E., and MacLean, James R., *Freedom to Learn,* Ontario, Canada: Addison-Wesley (Canada) Ltd. (1969) pages 29-52.

Excellent resource book for teachers. Chapter 3 deals with physical and equipment needs of classrooms. A few designs for storage boxes are included.

Blackwell, F. F. Nuffield Junior Science, *Apparatus, A Source Book of Information and Ideas.* London: William Collins , Sons & Co., Ltd., 1967. (Distributed by Agathon Press, Inc., 150 Fifth Avenue, N.Y., N.Y. 10011.)

Sections on light, sound, and heat may help teachers whose students are investigating physical improvements in the classroom. Appendices include instructions for building classroom furniture and equipment.

Early Childhood Education Study, *Building with Tubes, Building with Cardboard,* Newton, Massachusetts: Education Development Center (1970).

Both pamphlets contain useful ideas and helpful hints for working with cardboard materials.

Engle, Brenda S., *Arranging the Informal Classroom,* Newton, Massachusetts: Education Development Center (1973).

Various interest areas that make up an open classroom are described in this paperback book; ideas, suggestions, and instructions are included. The bibliography is worth reading.

Farallones Designs, *Farralones Scrapbook.* Berkeley: The Boys in the Back, 1971. (Order from Farallones Designs, Star Route, Point Reyes Station, California 94956.)

Two chapters are particularly useful: "Ways to Change Classrooms" and "Trash Can Do It."

Wastnedge, E. R., (editor), Nuffield Junior Science, *Teacher's Guide 1,* New York, New York: Agathon Press, Inc. (1967), pages 152-216.

An excellent chapter on classroom organization discusses arrangement, materials, storage, and display space.

Workshop for Learning Things. *Further Adventures of Cardboard Carpentry.* Watertown, Massachusetts: Workshop for Learning Things (5 Bridge Street, 02172), 1972. ($3.50)

Drawings and photographs accompany plans and building techniques for making Tri-Wall furniture.

4. GLOSSARY

The following definitions may be helpful to a teacher whose class is investigating a Classroom Design challenge. These terms may be used when they are appropriate for the children's work. For example, a teacher may tell the children that when they conduct surveys, they are collecting *data*. It is not necessary for the teacher or students to learn the definitions nor to use all of these terms while working on their challenge. Rather, the children will begin to use the words and understand the meanings as they become involved in their investigations.

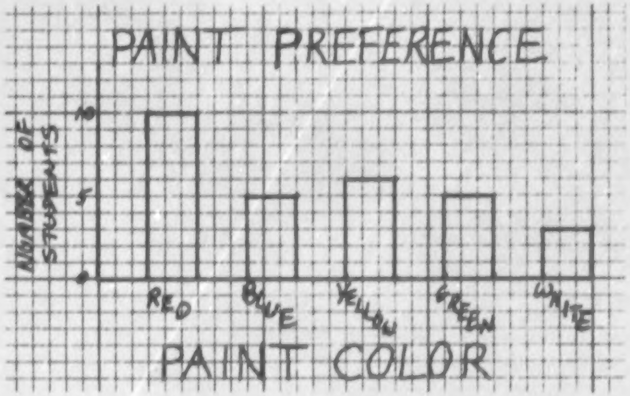
Average	The numerical value obtained by dividing the sum of the elements of a set of data by the number of elements in that set. Also called the mean.
Calibration	The setting and marking of an instrument to correspond to standard measurements.
Candle (Candela)	A unit of measurement of light intensity. Defined so that one square centimeter of platinum at its melting point has a light intensity of 60 candles.
Circuit	A path through which electricity can flow if the path is continuous.
Closed Circuit	A circuit that provides a continuous path for electricity.
Open Circuit	A circuit that does not provide a continuous path for electricity.
Parallel Circuits	A circuit in which two or more electrical components (such as bulbs and buzzers) are connected so that the electricity divides into two or more paths.
Series Circuit	A circuit in which the electricity flows through all components along a single path.
Short Circuit	A low resistance path resulting in too much current that may damage those components in the path.
Complement of a Set	See *Set*.

Conductor	Material that offers very little opposition to the flow of electricity, and therefore is used to carry or conduct electricity.
Conversion	A change from one form to another. Generally associated in mathematics and science with the change from one unit of measure to another or the change from one form of energy to another.
Correlation	A relationship between two sets of data.
Current	The flow of electric charge. Technically, the rate of flow of electric charge through a conductor: how much electric charge passes through a given point in a circuit in a given amount of time. Measured in amperes (amps).
Alternating Current (AC)	Electric current that flows first in one direction and then in the opposite direction in regular cycles. Most household current is AC.
Direct Current (DC)	Electric current that flows in only one direction. Current from batteries is DC.
Data	Any facts, quantitative information, or statistics.
Decibel	A unit of measurement of sound intensity. The number of decibels is equal to ten times the logarithm of the ratio of the sound intensity and a standard reference point. The reference point is the power required to produce a barely audible sound at a frequency of 1000 Hertz (i.e., a pitch nearly two octaves above middle C).
Degree	A unit of measurement of temperature or angle.
Distribution	The spread of data over the range of possible results.
Foot-Candle	A unit of measurement of illumination. A surface placed one foot from a light source having a light intensity of one candle has an illumination of one foot-candle.
Graph	A drawing or a picture of one or several sets of data.

Bar Graph

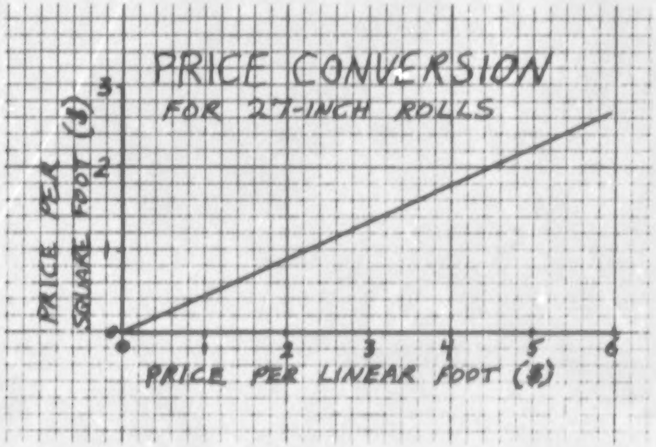
A graph of a set of measures or counts whose sizes are represented by the vertical (or horizontal) lengths of bars of equal widths. Example: Number of students preferring different colors for wall paint.

Paint Color	Number of Students
Red	10
Blue	5
Yellow	6
Green	5
White	3



Conversion Graph

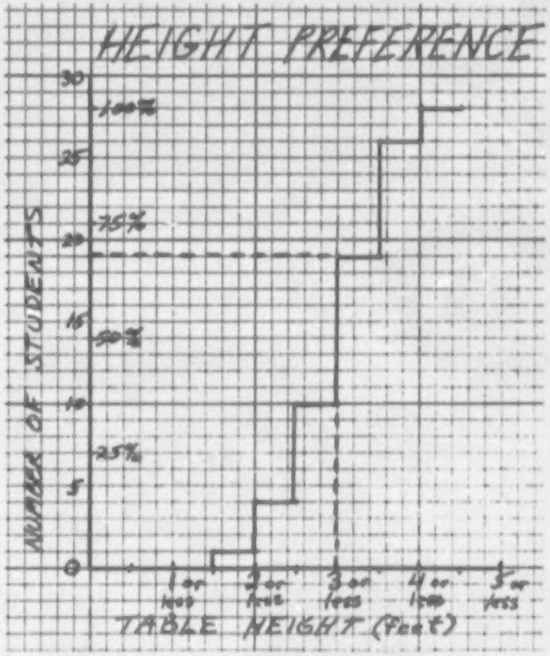
A line graph that is used to change one unit of measurement to another. For example, changing price per linear foot of curtain material to price per square foot (for a roll of given width).



Cumulative Distribution Graph

A graph that can be constructed from a histogram by computing running totals from the histogram data. The first running total is the first value in the histogram data (see table of values). The second running total is the sum of the first and second values of the histogram; the third is the sum of the first, second, and third values, and so on, The horizontal scale on the graph is similar to that of the histogram; the vertical scale goes from 0 to the total number of events observed or samples taken (in the example, the total number of students who expressed some preference for table height). Each vertical distance on the graph shows the running total of the number of samples taken that are less than or equal to the value shown on the horizontal scale; thus the graph below indicates that 19 students, or about 70 per cent, prefer a table height of three feet or less.

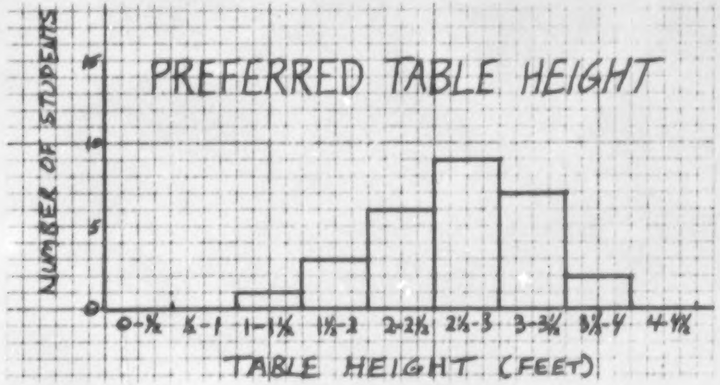
Height (ft.)	Number of Students
1½ or less	1
2 or less	4
2½ or less	10
3 or less	19
3½ or less	26
4 or less	28



Histogram

A type of bar graph that shows the distribution of the number of times that different measures or counts of the same event have occurred. A histogram always shows ordered numerical data on the horizontal axis. Example: Numbers of children who prefer different table heights.

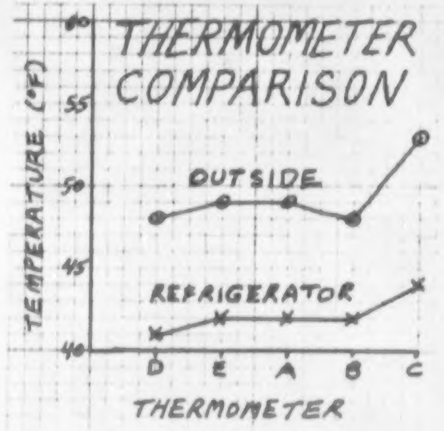
Height (ft.)	Number of Students
1-1½	1
1½-2	3
2-2½	6
2½-3	9
3-3½	7
3½-4	2



Line Chart

Sometimes a bar graph is represented by circles, crosses, or triangles, with lines connecting them so that it has the appearance of a line graph. (See *Line Graph*.) This line chart is a useful representation when two or more sets of data are shown on the same graph. Example: Readings from five thermometers for two different situations.

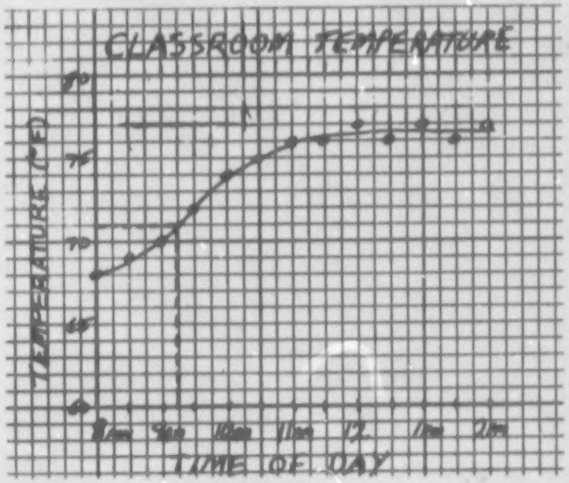
Thermometer	Temperature (°F)	
	Outside	Refrigerator
A	42	49
B	42	48
C	44	53
D	41	48
E	42	49



Line Graph

A graph in which a smooth line or line segments pass through or near points representing members of a set of data. Since the line represents an infinity of points, the variable on the horizontal axis must be continuous. If the spaces between the markings on the horizontal axis have no meaning, then the graph is not a line graph, but a line chart (see *Line Chart.*) Example: Temperature in one part of the classroom during the school day. (This is a line graph since you can tell from the graph that the temperature was about 71°F at 9:15 even though it wasn't measured at that time.

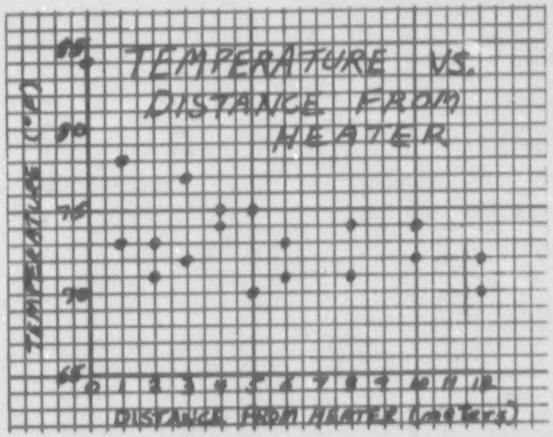
Time	Temperature (°F)
8:00 A.M.	68
8:30	69
9:00	70
9:30	72
10:00	74
10:30	75
11:00	76
11:30	76
12:00 P.M.	77
12:30	76
1:00	77
1:30	76
2:00	77



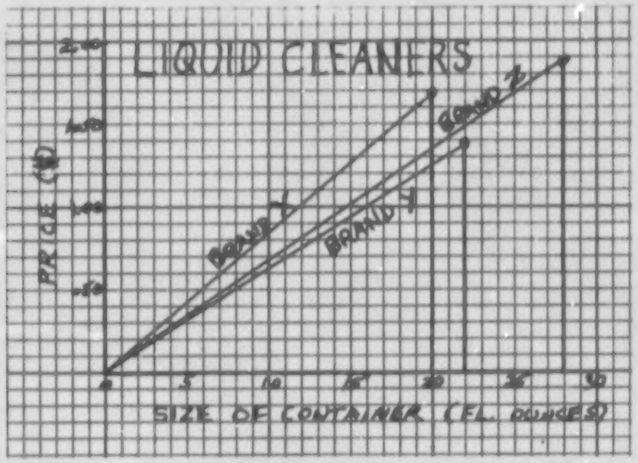
Scatter Graph

A graph showing a scatter of points, each of which represents two characteristics of the same thing. For example, in the graph below, each point represents a place in the classroom where the temperature was measured.

Distance (meters)	Temperature (°F)	
0	85	
1	78	73
2	73	71
3	77	72
4	75	74
5	75	70
6	73	71
8	74	71
10	74	72
12	72	70



*Slope Diagram**	A graphical means of comparing fractions or ratios. To represent the ratio a/b, plot the point (b,a) and draw a line from (b,a) to the origin, (0,0). The slope of this line represents the ratio a/b. By comparing the slopes of several lines, different ratios can be compared; the less steep the line, the smaller the ratio. For example, in the diagram showing the ratio of price to weight for different brands of liquid cleaner, the ratio of price to weight for Brand Y is less than that for Brand X or Z, and therefore, Brand Y costs the least per ounce.



Histogram	See *Graph*.
Hypothesis	A tentative conclusion made in order to test its implications or consequences.
Illumination (Illuminance)	A measure of how well-lit a surface is. More technically, a measure of how much light energy falls upon a given area in a given time. Measured in foot-candles.
Inference	An assumption derived from facts or information considered to be valid and accurate.
Insulator	A material that offers much opposition to the flow of electricity.
Intersection of Sets	See *Set*

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*Formerly called Triangle Diagram

Light Intensity (Luminous Intensity)	A measure of the brightness of a source of light. More technically, a measure of how much light energy is given off by a source in a given time per unit solid angle. Measured in candles for a point source; in candles/cm^2 for an extended (or a surface) source.
Mean	See *Average*.
Median	The middle value of a set of data in which the elements have been ordered from smallest to largest. The median value has as many elements above it as below it.
Mode	The element or elements in a set of data that occur most often.
Ordered Set	A set of data arranged from smallest to largest.
Per Cent	Literally per hundred. A ratio in which the denominator is always 100, e.g., 72 per cent = 72/100 = 0.72, where the symbol % represents 1/100.
Percentage	A part of a whole expressed in hundredths.
Population	Any group of objects (e.g., people, animals, items) or events from which samples are taken for statistical measurement.
Proportion	A statement of equality of two ratios, i.e., the first term divided by the second term equals the third term divided by the fourth term, e.g., 5/10 = 1/2. Also a synonym for ratio: when two quantities are in direct proportion, their ratios are the same.
Quartile	
First	The first quartile is the value of the quarter-way piece of data in an ordered set of data.
Third	The third quartile is the value of the three-quarter-way piece of data in an ordered set of data.
Interquartile Range	The range or length of the middle 50% of an ordered set of data; the difference between the first and third quartile.
Range	Mathematical: the difference between the smallest and the largest values in a set of data.

Rank	To order the members of a set according to some criterion, such as size or importance. Example: to put pieces of data from smallest to largest.
Ratio	The quotient of two denominate numbers or values indicating the relationship in quantity, size, or amount between two different things. For example, the ratio of the number of children who can use a piece of furniture to the area occupied by the furniture might be 10 children/4½ square meters or 10 children:4½ square meters.
Recycle	To process a discarded item for reuse, either for its original purpose or for a new purpose.
Resistance	The opposition that a device or material offers to the flow of electricity, measured in ohms.
Sample	A representative fraction of a population studied to gain information about the whole population.
Sample Size	The number of elements in a sample.
Scale	A direct proportion between two sets of dimensions (as between the dimensions in a drawing of a lab and the actual lab).
Scale Drawing	A drawing whose dimensions are in direct proportion to the object drawn.
Scale Map	A map whose dimensions are in direct proportion to the dimensions of the area represented.
Scale Model	A three-dimensional representation constructed to scale.
Schematic	A circuit diagram in which components are represented by symbols.
Set	A collection of characteristics, persons, or objects. Each thing in a set is called a member or an element.
Set Theory	The branch of mathematics that deals with the nature and relations of sets.

Complement of a Set	The set of all elements in the universal set but not in the given set. For example, if the universal set is the set of all the students in a class, then the set of girls is the complement of the set of boys.
Intersection of Sets	The set of elements common to two or more sets. For example, if set A is all girls and set B is all blue-eyed children, the intersection of set A and set B is the set of blue-eyed girls.
Universal Set	A set that contains all elements relevant to a particular problem.
Venn Diagram	A drawing used to illustrate the relationship between sets.
Sound Intensity	Level or loudness of a sound. A measure of how much sound energy flows through a given area in a given time. Measured in decibels or watts/cm^2.
Sound Level Meter	An instrument used to measure sound intensity.
Statistics	The science of drawing conclusions or making predictions using a collection of quantitative data.
Switch	A device for opening and closing a circuit.
Tally	A visible record used to keep a count of some set of data, especially a record of the number of times one or more events occur. Example: A record of the number of times, during science period, that someone runs down the stairs outside the classroom.
Temperature	A measure of hotness or coldness. Technically, an indication of the average kinetic energy of molecules. Temperature is commonly measured in degrees Fahrenheit or degrees centigrade (Celsius).
Thermometer, Centigrade (or Celsius)	A thermometer on which the interval between the normal freezing and boiling points of water is divided into 100 parts or degrees, ranging from 0°C to 100°C.
Thermometer, Fahrenheit	A thermometer on which the interval between the normal freezing and boiling points of water is divided into 180 parts or degrees, ranging from 32°F to 212°F.

Voltage	A measure of the electrical energy per unit charge in a circuit. For a given circuit, as the voltage increases, the current increases.
Watt	A unit of measurement of power (energy per unit of time or work per unit of time.) Although light bulbs are rated in watts, the wattage indicates both heat and light output.
Wire Gauge	AWG (American Wire Gauge)—a system for numbering wire sizes; the larger the AWG number, the smaller the diameter of wire.

E. Skills, Processes, and Areas of Study Utilized in Classroom Design

The unique aspect of USMES is the degree to which it provides experience in the process of solving real problems. Many would agree that this aspect of learning is so important as to deserve a regular place in the school program even if it means decreasing to some extent the time spent in other important areas. Fortunately, real problem solving is also an effective way of learning many of the skills, processes, and concepts in a wide range of school subjects.

On the following pages are five charts and an extensive, illustrative list of skills, processes, and areas of study that are utilized in USMES. The charts rate Classroom Design according to its potential for learning in various categories of each of five subject areas--real problem solving, mathematics, science, social science, and language arts. The rating system is based on the amount that each skill, process, or area of study within the subject areas is used--extensive (1), moderate (2), some (3), little or no use (-). (The USMES Guide contains a chart that rates all USMES units in a similar way.)

The chart for real problem solving presents the many aspects of the problem-solving process that students generally use while working on an USMES challenge. A number of the steps in the process are used many times and in different orders, and many of the steps can be performed concurrently by separate groups of students. Each aspect listed in the chart applies not only to the major problem stated in the unit challenge but also to many of the tasks each small group undertakes while working on a solution to the major problem. Consequently, USMES students gain extensive experience with the problem-solving process.

The charts for mathematics, science, social science, and language arts identify the specific skills, processes, and areas of study that may be learned by students as they respond to a Classroom Design challenge and become involved with certain activities. Because the students initiate the activities, it is impossible to state unequivocally which activities will take place. It is possible, however, to document activities that have taken place in USMES classes and identify those skills and processes that have been used by the students.

Knowing in advance which skills and processes are likely to be utilized in Classroom Design and knowing the extent that they will be used, teachers can postpone the teaching of those skills in the traditional manner until later in the year. If the students have not learned them during their USMES activities by that time, they can study them in the usual way. Further, the charts enable a teacher to integrate USMES more readily with other areas of classroom work. For example, teachers may teach fractions during math period when fractions are also being learned and utilized in the students' USMES activities. Teachers who have used USMES for several successive years have found that students are more motivated to learn basic skills when they have determined a need for them in their USMES activities. During an USMES session the teacher may allow the students to learn the skills entirely on their own or from other students, or the teacher may conduct a skill session as the need for a particular skill arises.

Because different USMES units have differing emphases on the various aspects of problem solving and varying amounts of possible work in the various subject areas, teachers each year might select several possible challenges, based on their students' previous work in USMES, for their class to consider. This choice should provide students with as extensive a range of problems and as wide a variety of skills, processes, and areas of study as possible during their years in school. The charts and lists on the following pages can also help teachers with this type of planning.

Some USMES teachers have used a chart similar to the one given here for real problem solving as a record-keeping tool, noting each child's exposure to the various aspects of the process. Such a chart might be kept current by succeeding teachers and passed on as part of a student's permanent record. Each year some attempt could be made to vary a student's learning not only by introducing different types of challenges but also by altering the specific activities in which each student takes part. For example, children who have done mostly construction work in one unit may be encouraged to take part in the data collection and data analysis in their next unit.

Following the rating charts are the lists of explicit examples of real problem solving and other subject area skills, processes, and areas of study learned and utilized in Classroom Design. Like the charts, these lists are based on documentation of activities that have taken place in USMES classes. The greater detail of the lists allows teachers to see exactly how the various basic skills, processes, and areas of study listed in the charts may arise in Classroom Design.

The number of examples in the real problem solving list have been limited because the list itself would be unreasonably long if all the examples were listed for some of the categories. It should also be noted that the example(s) in the first category--*Identifying and Defining Problems*--have been limited to the major problem that is the focus of the unit. During the course of their work, the students will encounter and solve many other, secondary problems, such as the problem of how to display their data or how to draw a scale layout.

Breaking down an interdisciplinary curriculum like USMES into its various subject area components is a difficult and highly inexact procedure. Within USMES the various subject areas overlap significantly, and any subdivision must be to some extent arbitrary. For example, where does measuring as a mathematical skill end and measurement as science and social science process begin? How does one distinguish between the processes of real problem solving, of science, and of social science? Even within one subject area, the problem still remains--what is the difference between graphing as a skill and graphing as an area of study? This problem has been partially solved by judicious choice of examples and extensive cross-referencing.

Because of this overlap of subject areas, there are clearly other outlines that are equally valid. The scheme presented here was developed with much care and thought by members of the USMES staff with help from others knowledgeable in the fields of mathematics, science, social science, and language arts. It represents one method of examining comprehensively the scope of USMES and in no way denies the existence of other methods.

REAL PROBLEM SOLVING	Overall Rating
Identifying and defining problem.	1
Deciding on information and investigations needed.	1
Determining what needs to be done first, setting priorities.	2
Deciding on best ways to obtain information needed.	1
Working cooperatively in groups on tasks.	1
Making decisions as needed.	1
Utilizing and appreciating basic skills and processes.	1
Carrying out data collection procedures--observing, surveying, researching, measuring, classifying, experimenting, constructing.	1
Asking questions, inferring.	1
Distinguishing fact from opinion, relevant from irrelevant data, reliable from unreliable sources.	1

REAL PROBLEM SOLVING	Overall Rating
Evaluating procedures used for data collection and analysis. Detecting flaws in process or errors in data.	1
Organizing and processing data or information.	1
Analyzing and interpreting data or information.	1
Predicting, formulating hypotheses, suggesting possible solutions based on data collected.	1
Evaluating proposed solutions in terms of practicality, social values, efficacy, aesthetic values.	1
Trying out various solutions and evaluating the results, testing hypotheses.	1
Communicating and displaying data or information.	1
Working to implement solution(s) chosen by the class.	1
Making generalizations that might hold true under similar circumstances; applying problem-solving process to other real problems.	1

KEY: 1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use

MATHEMATICS	Overall Rating
Basic Skills	
Classifying/Categorizing	2
Counting	1
Computation Using Operations	
Addition/Subtraction	1
Multiplication/Division	1
Fractions/Ratios/Percentages	1
Business and Consumer Mathematics/ Money and Finance	3
Measuring	1
Comparing	2
Estimating/Approximating/Rounding Off	1
Organizing Data	1
Statistical Analysis	2
Opinion Surveys/Sampling Techniques	2
Graphing	2
Spatial Visualization/Geometry	1
Areas of Study	
Numeration Systems	2
Number Systems and Properties	1
Denominate Numbers/Dimensions	1
Scaling	1
Symmetry/Similarity/Congruence	3
Accuracy/Measurement Error/ Estimation/Approximation	1
Statistics/Random Processes/Probability	2
Graphing/Functions	2
Fraction/Ratio	1
Maximum and Minimum Values	3
Equivalence/Inequality/Equations	2
Money/Finance	3
Set Theory	3

SCIENCE	Overall Rating
Processes	
Observing/Describing	1
Classifying	2
Identifying Variables	2
Defining Variables Operationally	2
Manipulating, Controlling Variables/ Experimenting	2
Designing and Constructing Measuring Devices and Equipment	2
Inferring/Predicting/Formulating, Testing Hypotheses/Modeling	1
Measuring/Collecting, Recording Data	1
Organizing, Processing Data	1
Analyzing, Interpreting Data	1
Communicating, Displaying Data	1
Generalizing/Applying Process to New Problems	1
Areas of Study	
Measurement	1
Motion	-
Force	-
Mechanical Work and Energy	-
Solids, Liquids, and Gases	3
Electricity	3
Heat	1
Light	1
Sound	1
Animal and Plant Classification	-
Ecology/Environment	2
Nutrition/Growth	-
Genetics/Heredity/Propagation	-
Animal and Plant Behavior	-
Anatomy/Physiology	3

1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use

SOCIAL SCIENCE	Overall Rating
Process	
Observing/Describing/Classifying	1
Identifying Problems, Variables	1
Manipulating, Controlling Variables/Experimenting	2
Inferring/Predicting/Formulating, Testing Hypotheses	2
Collecting, Recording Data/Measuring	1
Organizing, Processing Data	1
Analyzing, Interpreting Data	1
Communicating, Displaying Data	1
Generalizing/Applying Process to Daily Life	1
Attitudes/Values	
Accepting Responsibility for actions and results	1
Developing interest and involvement in human affairs	1
Recognizing the importance of individual and group contributions to society	1
Developing inquisitiveness, self-reliance, and initiative	1
Recognizing the values of cooperation, group work, and division of labor	1
Understanding the modes of inquiry used in the sciences, appreciating their power and precision	1
Respecting the views, thoughts, and feelings of others	1
Being open to new ideas and information	1
Learning the importance and influence of values in decision making	1
Areas of Study	
Anthropology	-
Economics	2
Geography/Physical Environment	3
Political Science/Government Systems	2
Recent Local History	-
Social Psychology/Individual and Group Behavior	3
Sociology/Social Systems	2

LANGUAGE ARTS	Overall Rating
Basic Skills	
Reading	
Literal Comprehension: Decoding Words, Sentences, Paragraphs	2
Critical Reading: Comprehending Meanings, Interpretation	2
Oral Language	
Speaking	1
Listening	1
Memorizing	-
Written Language	
Spelling	3
Grammar: Punctuation, Syntax, Usage	3
Composition	3
Study Skills	
Outlining/Organizing	3
Using References and Resources	3
Attitudes/Values	
Appreciating the value of expressing ideas through speaking and writing	1
Appreciating the value of written resources	3
Developing an interest in reading and writing	3
Making judgments concerning what is read	2
Appreciating the value of different forms of writing, different forms of communication	1

KEY: 1 = extensive use, 2 = moderate use
3 = some use, - = little or no use

REAL PROBLEM SOLVING IN CLASSROOM DESIGN

Identifying and Defining Problems	• Students decide overheating is a problem in their classroom. • See also SOCIAL SCIENCE list: *Identifying Problems, Variables*.
Deciding on Information Needed	• After a discussion students decide they need to collect data on classroom temperature in different parts of the room. • After analyzing temperature readings students decide more data at different times of the day are needed. • Students decide that they need to know more general information about heat and temperature.
Determining What Needs to Be Done First, Setting Priorities	• Students decide to measure classroom temperature and to find out the extent of the overheating problem before trying solutions. • Students borrow and calibrate thermometers before measuring temperature.
Deciding on Best Ways to Obtain Information Needed	• Children establish a schedule for systematically measuring temperature under different conditions, e.g., windows open and windows closed. • Children decide that, as a check, at least two children will read each thermometer when measuring temperature. • Children decide to conduct performance tests to see whether overheating hinders their work, and if so, to what extent. • Children decide to do research in library on topics of heat and temperature.
Working Cooperatively in Groups on Tasks	• Students form groups to collect data on temperature in different parts of the classroom and to measure the classroom and furniture and make a scale layout.

Making Decisions as Needed	• Students decide to work in groups so that more can be accomplished. • Students decide that rearranging desks is the best way to solve the temperature problem. • Students decide to make a presentation to the principal to get approval for their plans to alter classroom.
Utilizing and Appreciating Basic Skills and Processes	• Students measure the classroom and furniture to draw scale layout. • Students divide to obtain measurements for scale layout. • Students draw graphs of temperature changes during the day. • Students recognize that improving the classroom will help many people besides themselves, namely children in future classes who will use the room. • Students give oral presentations to principal. • See also MATHEMATICS, SCIENCE, SOCIAL SCIENCE, and LANGUAGE ARTS lists.
Carrying Out Data Collection Procedures--Opinion Surveying, Researching, Measuring, Classifying, Experimenting, Constructing	• Students measure temperature in the classroom. • Students conduct opinion survey to find out where people want to sit. • Students look through library books to learn about heat and temperature. • Students measure the classroom and furniture. • See also MATHEMATICS list: *Classifying/Categorizing; Measuring.* • See also SCIENCE list: *Observing/Describing; Classifying; Manipulating, Controlling Variables/Experimenting; Designing and Constructing Measuring Devices and Equipment; Measuring/Collecting, Recording Data.* • See also SOCIAL SCIENCE list: *Observing/Describing; Classifying; Manipulating, Controlling Variables/Experimenting; Collecting, Recording Data/Measuring.*
Asking Questions, Inferring	• Students ask whether overheating hinders their work and infer from performance-test data that it does. • Students ask whether rearranging furniture in classroom will make them more comfortable. They infer from temperature data that being farther from the radiator will make overheating less of a problem.

Asking Questions, Inferring (cont.)	• See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling.* • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Distinguishing Fact from Opinion, Relevant from Irrelevant Data, Reliable from Unreliable Sources	• Students recognize the qualitative aspects of obtaining data from opinion surveys as distinct from data they gather by measuring a physical quantity such as temperature. • Students recognize that outdoor temperature is not a good indication of classroom temperature.
Evaluating Procedures Used for Data Collection and Analysis, Detecting Flaws in Process or Errors in Data	• Students discuss the manner in which classroom temperature was measured, then refine their procedure. • Children decide that their seating-preference survey needs improvement and discuss changes they need to make in it. • Students measuring classroom with a variety of measuring devices obtain widely varying results. They discuss the discrepancies and choose one instrument and one procedure for final measurements. • See also MATHEMATICS list: *Estimating/Approximating/Rounding Off.*
Organizing and Processing Data	• Students record their temperature data on a chart. • Students arrange desks on a scale model according to seating preferences. • See also MATHEMATICS list: *Organizing Data.* • See also SCIENCE and SOCIAL SCIENCE lists: *Organizing, Processing Data.*
Analyzing and Interpreting Data	• Students find the median and range of room temperature during the day. • Students make a three-dimensional graph to show uneven distribution of temperature. • See also MATHEMATICS list: *Comparing; Statistical Analysis; Opinion Surveys/Sampling Techniques; Graphing; Maximum and Minimum Values.* • See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data.*

Predicting, Formulating Hypotheses, Suggesting Possible Solutions Based on Data Collected	• Students predict that their performance on tests will improve if they are more comfortable. • After investigating, students suggest that desks be rearranged as a way of combating overheating. • After conducting surveys of seating preferences, students recommend a revolving seating plan so that each child will, at some time, be satisfied. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling.* • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Evaluating Proposed Solutions in Terms of Practicality, Social Values, Efficacy, Aesthetic Values	• Students discuss advantages and disadvantages of proposed arrangement of desks. • Students discuss whether proposed arrangement will be fair.
Trying Out Various Solutions and Evaluating the Results, Testing Hypotheses	• After implementing a schedule for opening windows, the class collects further data to determine the effect of their change. • Students use a scale layout of the classroom to find the best arrangement of desks. • Students discuss how they feel about the new look of their classroom and whether they are more comfortable. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling.* • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Communicating and Displaying Data or Information	• Students make a line graph to show variation in temperature during the school day. • Students draw a scale layout of the classroom. • See also MATHEMATICS list: *Graphing; Scaling.* • See also SCIENCE and SOCIAL SCIENCE lists: *Communicating, Displaying Data.* • See also LANGUAGE ARTS list.
Working to Implement Solution(s) Chosen by the Class	• Students make a presentation of rearrangement plans to principal. • Students arrange the classroom according to their chosen plan. • Students recommend that the heat be turned down earlier in the day.

Making Generalizations That Might Hold True Under Similar Circumstances; Applying Problem-Solving Process to Other Real Problems	• Students who have drawn graphs to display data in one instance more readily draw graphs in other instances. • Students working on Classroom Design apply skills they have acquired to their work on Classroom Management. • See also SCIENCE list: *Generalizing/Applying Process to New Problems.* • See also SOCIAL SCIENCE list: *Generalizing/Applying Process to Daily Life.*

Basic Skills

Classifying/Categorizing

- Categorizing characteristics or properties of construction materials.
- Categorizing characteristics of construction materials in more than one way.
- Organizing and classifying sets of materials, activities, or information.
- Distinguishing sets and subsets of quantitative survey data on preferred desk and table sizes.
- Using the concepts and language of sets (subsets, unions, intersections, set notations) for making seating plans according to student preferences.
- See also SCIENCE list: *Classifying.*
- See also SOCIAL SCIENCE list: *Observing/Describing/Classifying.*

Counting

- Counting votes to decide which classroom problem to work on first.
- Counting survey data or questionnaire data on preferences for rug or paint color.
- Counting the number of seconds it takes for the whole class to evacuate the room.
- Counting to read scales on thermometers, light meters, or sound meters.
- Counting by sets to find a scale for graph axes.

Computation Using Operations: Addition/Subtraction

- Adding one-, two-, or three-digit whole numbers to find the total tally of time spent in classroom or the total measurement of table area needed to accommodate a given number of students.
- Adding minutes and seconds when timing how long it takes to find art supplies.
- Subtracting distance measurements to see how much room is left after a cabinet is placed against one wall of the classroom.
- Subtracting one-, two-, or three-digit whole numbers to find ranges for graph axes, for measurement data, or to compare sets of data.

Computation Using Operations: Multiplication/Division	• Using multiplication and division to increase or decrease measurements for scale drawings or scale models. • Multiplying whole numbers to find the total measurement of material needed to make curtains for several identical windows. • Multiplying or dividing to find a scale for graph axes. • Dividing to find a unit measure. • Multiplying and dividing to convert from inches to feet. • Dividing to calculate the average of temperature readings. • Dividing to calculate ratios, fractions, or per cents.
Computation Using Operations: Fractions/Ratios/Percentages	• Using mixed numbers to perform calculations, such as determining measurements for shelf or table. • Changing fractions to higher or lower terms (equivalent fractions) to perform operations such as calculating dimensions for furniture. • Using ratios and fractions to convert from yards to feet. • Using ratios to increase or decrease measurements for a scale drawing of the classroom or a scale model of a table. • Using fractions in measurement, graphing, graphic comparisons, scale drawings, or scale models. • Calculating actual measurements from scale drawings using the ratio of the scale drawing. • Calculating percentages of students that prefer particular table heights.
Computation Using Operations: Business and Consumer Mathematics/ Money and Finance	• Adding, subtracting, multiplying, and dividing dollars and cents to analyze costs of building classroom furniture, painting the classroom, or carpeting the floor. • Gaining experience with finance: sources, uses, and limitations of revenues for classroom decorations, supplies for constructing furniture, etc. • Investigating costs of equipment for classroom vs. use of equipment and budget restrictions. • Using comparison when shopping for materials. • Using slope diagrams to compare cost per ounce for different brands of liquid cleaner.

Measuring

- Converting from meters to centimeters.
- Using arbitrary units (e.g., children's feet) to measure dimensions of the classroom.
- Using different measuring tools to measure light, sound, temperature, and length.
- Reading thermometers or other measuring devices accurately.
- Timing--using a wristwatch or clock--how long it takes the class to evacuate room.
- See also SCIENCE list: *Measuring/Collecting, Recording Data.*
- See also SOCIAL SCIENCE list: *Collecting, Recording Data/ Measuring.*

Comparing

- Comparing measurements obtained by using a meter stick and a tape measure.
- Comparing qualitative information, such as safety regulations, gathered from various sources, such as the fire department, school board, and city hall.
- Comparing qualitative with quantitative data.
- Comparing estimated and actual results of light-intensity measurement.
- Making graphic comparisons of fractions and ratios on body proportions to determine table heights.
- Comparing costs of various classroom improvements, e.g., rug, paint, curtains, etc.
- Using the concept of *greater than* and *less than* in making comparisons of the space required for different classroom activities.
- See also SCIENCE list: *Analyzing, Interpreting Data.*
- See also SOCIAL SCIENCE list: *Analyzing, Interpreting Data.*

Estimating/Approximating/ Rounding Off

- Estimating the number of people who will use a "quiet corner."
- Estimating sizes of desks, measurements of the classroom, the amount of space needed for a classroom activity, or the cost of construction materials.
- Estimating the placement of decorative posters on walls at heights determined by eyeballing.
- Determining when a measurement of light or sound intensity is likely to be accurate enough for a particular purpose.
- Using approximation in constructing shelves.
- Rounding off measurements while measuring temperature.
- Rounding off data after measuring dimensions of the room or furniture.

Organizing Data

- Tallying votes to determine priorities.
- Tallying survey data or questionnaire data on classroom problems.
- Tallying on bar graphs or histograms.
- Ordering real numbers on a number line or graph axis.
- Ordering the steps in a process.
- Ordering test or survey results on preferred table heights.
- Ordering inches, feet, yards.
- See also SCIENCE list: *Organizing, Processing Data*.
- See also SOCIAL SCIENCE list: *Organizing, Processing Data*.

Statistical Analysis

- Finding the median in an ordered set of data on preferences for shelf height.
- Taking repeated measurements and using the median measurement.
- Finding and comparing medians and modes of data on sound levels.
- Determining the range of data on room temperature or light intensity.
- See also SCIENCE list: *Analyzing, Interpreting Data*.
- See also SOCIAL SCIENCE list: *Analyzing, Interpreting Data*.

Opinion Surveys/Sampling Techniques

- Conducting surveys on decoration preferences; defining data collection methods and the makeup and size of the sample.
- Devising methods of obtaining quantitative information about subjective opinions such as students' feelings about their classroom.
- Evaluating survey methodology, data obtained, and the size and type of samples.
- See also SCIENCE list: *Analyzing, Interpreting Data*.
- See also SOCIAL SCIENCE list: *Analyzing, Interpreting Data*.

Graphing

- Using alternative methods of displaying data, e.g., charts, graphs.
- Making a graph form--dividing axes into parts and deciding on an appropriate scale.
- Representing data on graphs.
  - Bar graph--number of students perferring different paint colors.
  - Line graph--classroom temperature during the day.

Graphing (cont.)

    - Histogram--number of students preferring different table heights.
    - Conversion graph--price per linear foot to price per square foot for roll of material.
    - Scatter graph--classroom temperature at different distances from heater.
    - Cumulative distribution graph--table height preferences of students.
- Using three-dimensional graphical representations.
- Obtaining information from graphs.
- Representing several sets of data on one graph--classroom temperature measured during two different days.
- See also SCIENCE list: *Communicating, Displaying Data*.
- See also SOCIAL SCIENCE list: *Communicating, Displaying Data*.

Spatial Visualization/Geometry

- Drawing or constructing a design or model of a table.
- Using geometric figures to understand and utilize relationships such as area-to-perimeter for different shapes of table tops.
- Using standard mensurational formulas, e.g., A = L x W.
- Measuring and constructing scale layouts using rulers, compasses, and protractors.
- Using spatial arrangements to convey information on the best furniture arrangement for the classroom.
- Making a flow diagram of traffic patterns that develop when the entire class exits or enters the room.

Areas of Study

Numeration Systems

- Using the decimal system in measuring room dimensions for a scale drawing.
- Using fractions in measuring the area to be covered by a carpet.
- Using the decimal system in calculating costs of materials such as paint, lumber, and carpeting.

Number Systems and Properties

- See *Computation Using Operations*.

Denominate Numbers/Dimensions

- See *Measuring*.

Scaling	• Deriving information from scale drawings of the classroom and scale models of furniture. • Finding an appropriate scale (proportion) for the scale drawing or scale model. • Using a scale to draw and make representations in the scale drawing or scale model. • Making a scale drawing of the classroom or a scale model of furniture.
Symmetry/Similarity/Congruence	• See *Spatial Visualization/Geometry.*
Accuracy/Measurement Error/ Estimation/Approximation	• See *Measuring* and *Estimating/Approximating/Rounding Off.*
Statistics/Random Processes/ Probability	• See *Statistical Analysis.*
Graphing/Functions	• See *Graphing.*
Fraction/Ratio	• See *Computation Using Operations: Fractions/Ratios/ Percentages.*
Maximum and Minimum Values	• Minimizing space and cost in recommending and designing classroom equipment or furniture. • Determining a practical table-top shape that yields maximum perimeter/area ratio (to minimize material usage).
Equivalence/Inequality/Equations	• See *Comparing* and *Computation Using Operations.*
Money/Finance	• See *Computation Using Operations: Business and Consumer Mathematics/Money and Finance.*
Set Theory	• See *Classifying/Categorizing.*

ACTIVITIES IN CLASSROOM DESIGN UTILIZING SCIENCE

Process	
Observing/Describing	• Observing changes in temperature by reading a homemade or commercial thermometer. • Observing that noise from a classroom can be heard in an adjacent room. • Describing the various noises in the room that cause distraction. • See also SOCIAL SCIENCE list: *Observing/Describing/Classifying*.
Classifying	• Determining which parts of the room are hot and which are cold. • Determining which portions of the room are well-lighted and which are dark. • See also MATHEMATICS list: *Classifying/Categorizing*. • See also SOCIAL SCIENCE list: *Observing/Describing/Classifying*.
Identifying Variables	• Identifying temperature as one of the things to be measured. • Identifying time of day as one of the things to be controlled. • Identifying temperature (light, noise) as one of the things to be changed to improve the room. • See also SOCIAL SCIENCE list: *Identifying Problems/Variables*.
Defining Variables Operationally	• Defining room temperature as the temperature measured by a thermometer in degrees centigrade or Fahrenheit at some given point in the room (or as the average taken at several points). • Defining noise level as the VU-meter reading on a tape recorder when the volume is set at five.

Manipulating, Controlling Variables/Experimenting	• Measuring temperature under various conditions--door open, door closed, windows open, windows closed, etc. • Designing and conducting experiments to compare soundproofing ability of different materials. • See also SOCIAL SCIENCE list: *Manipulating, Controlling Variables/Experimenting.*
Designing and Constructing Measuring Devices and Equipment	• Constructing devices to measure light or sound levels in various parts of the room.
Inferring/Predicting/Formulating, Testing Hypotheses/Modeling	• Inferring from performance-test data that overheating hinders class work. • Deciding that opening windows and doors does help to lower the temperature in the classroom. • Predicting that painting bulletin boards bright colors will help improve lighting in darker areas. • Making scale layouts of possible furniture arrangements. • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Measuring/Collecting, Recording Data	• Using thermometers to measure temperature in different parts of the room and recording readings on a drawing of the classroom. • Measuring the classroom before constructing a scale layout to determine the best arrangement of furniture. • See also MATHEMATICS list: *Measuring.* • See also SOCIAL SCIENCE list: *Collecting, Recording Data/Measuring.*
Organizing, Processing Data	• Ordering temperature data according to time of day and day of week. • Tabulating measurements of the room and the furniture before constructing a scale layout. • See also MATHEMATICS list: *Organizing Data.* • See also SOCIAL SCIENCE list: *Organizing, Processing Data.*

Analyzing, Interpreting Data	• Calculating the average temperature in each part of the room for the entire week. • Determining colors for bulletin boards from preference-survey data. • See also MATHEMATICS list: *Comparing; Statistical Analysis; Opinion Surveys/Sampling Techniques; Graphing; Maximum and Minimum Values.*
Communicating, Displaying Data	• Making a dimensioned sketch of proposed table to get approval from class. • Showing temperature data on drawing of the classroom or on line graph. • See also MATHEMATICS list: *Graphing.* • See also SOCIAL SCIENCE list: *Communicating, Displaying Data.* • See also LANGUAGE ARTS list.
Generalizing/Applying Process to New Problems	• Applying skills acquired from work on Classroom Design to work on Classroom Management. • Using knowledge acquired from working on one aspect of the classroom to help solve other problems associated with the physical layout or design of the room. • See also SOCIAL SCIENCE list: *Generalizing/Applying Process to Daily Life.*

Areas of Study

Measurement	• Measuring the classroom area and the furniture in it using meter sticks, tape measures, and rulers. • Measuring various body parts, height, weight, using standard and non-standard units of measure. • Using stopwatches to measure the time it takes the class to evacuate the room during a fire drill. • Measuring the amount of space required for each child sitting and working at a table. • Measuring light intensity or sound levels with homemade or commercial instruments. • Measuring temperature with Fahrenheit and centigrade thermometers. • See also MATHEMATICS list: *Measuring.*

Force	• Observing that saber saws are faster and require less effort to operate than hand saws for cutting Tri-Wall or lumber. • Observing that force must be exerted to hammer nails into wood, noting that the hammer multiplies the force that is exerted. • Building tables or shelves with an effort to make them sturdy.
Friction	• Becoming aware of friction when observing that as a piece of wood is sanded it becomes smoother and offers less resistance to the motion of the sandpaper. • Observing, while testing the levelness of a table top, that some articles, such as pencils, will tend to roll if the table is not level, whereas other objects, such as books, will remain stationary because rolling friction is less than sliding friction. • Observing that a blade becomes warmer when a piece of wood is sawed vigorously because doing work against the force of friction generates heat.
Weight	• Observing the significance of gravity (weight) while testing the sturdiness of Tri-Wall tables.
Mechanical Work and Energy	• Noting that work is done and energy expended when nails are hammered into wood. • Observing that electrical energy is transformed into mechanical energy when sewing machines are used to make curtains or when power tools are used to build furniture. • Observing that wood blocks become warm when sanded vigorously as mechanical energy is transformed into heat energy. • See also *Force*.
Solids, Liquids, and Gases	
States of Matter	• Observing that glue is available in liquid or solid form with different properties. • Observing that a glue gun turns a cool stick of glue into a hot liquid glue.

Properties of Matter

- Observing that different construction materials, such as lumber and Tri-Wall, have different properties that make them useful for different tasks.
- Observing, while mixing tempera paints or dyes, that the dry powder mixes uniformly with water.
- Observing that paper materials available for making posters and other decorations have different colors and different weights.
- Observing that glues, lumber, paints, wall-coverings, and other materials have particular odors.

Electricity

- Observing that electricity can light bulbs and that electrical energy can be transformed into light energy.
- Causing a bulb to light by making a circuit.
- Observing that electricity does not flow through the insulation on a wire.
- Observing that the light goes on when the switch is closed and goes off when the switch is open.
- Observing that chemical energy stored in a battery can be transformed into electrical energy.
- Observing that no current flows when both positive or both negative ends of two batteries with the same voltage are placed together.
- Observing that bulbs burn brighter when more batteries are properly added to the circuit.
- Observing that different bulbs require more or fewer batteries to operate at the same level of brightness.
- Observing that adding more bulbs in a series or adding a greater length of wire to a circuit reduces the flow of electricity--bulbs get dimmer.
- Observing differences in the brightness of bulbs in a parallel circuit and a series circuit.
- Discovering that short circuits are dangerous and produce hot wires/burned fingers.
- Observing that plugging in the tape recorder enables the equipment to be turned on.
- Observing that tape recorders, saber saws, and other electrically powered devices go on when the switch is closed and go off when the switch is open.
- Observing that electricity can be transformed into mechanical energy (saber saw, electric drill, sewing machine, etc.), into heat energy (glue gun, iron, etc.), into chemical energy (battery charger).

Heat/Temperature	• Observing that the dark surfaces near the windows are hotter to the touch than the lighter surfaces. • Observing and measuring changes in temperature by reading a homemade or commercial thermometer. • Observing that some machines (glue gun, electric iron) generate heat when turned on as electrical energy is transformed into heat energy. • Observing an increase in temperature outside during the day as the earth absorbs more radiant heat and light from the sun. • Observing that temperature need not be the same in all parts of the classroom.
Light	• Observing that a glare is produced when a light source shines directly on the chalkboard and that light rays are reflected from the shiny, smooth surface. • Observing that chemical energy of batteries can be transformed into light energy in a flashlight or small desk lamp. • Observing that under the same conditions a white-walled side of a room is lighter than a dark-walled side because white-colored walls reflect more light than do black or very dark-colored walls. • Observing that a lighted area becomes darker when an object is placed between the area and the light source because some light is blocked (reflected or absorbed) by the object. • Observing that the room is brighter without curtains or shades on the windows because light rays can pass readily through certain (transparent) substances. • Observing that the room is darker with the shades or curtains drawn because light rays are absorbed or reflected by certain opaque substances. • Observing that the side of the room near the windows is brighter than the rest of the room and that the intensity of illumination decreases as the distance from the light source increases. • Observing that the amount of light present may affect the quality of work being done. • Measuring light intensity with homemade or commercial light meters.

Sound	• Assessing or measuring noise levels using professional sound-level meters or tape-recorder meters. • Sometimes observing movement in an object producing sound. • Observing that classmates located in various parts of the room respond to a single spoken direction from the teacher standing in one location. Sound travels in all directions from the source of the sound. • Observing that noise from one classroom can sometimes be heard in an adjacent room. • Observing that some of the electrical energy supplied to power tools is transformed into sound energy (noise). • Observing that sounds differ in tone, pitch, loudness, and quality. • Observing that noise levels in the classroom are lower when curtains or acoustical barriers are used to absorb the sound. • Observing that a sound becomes less intense as it moves away from its source. • Observing that sound travels around objects much more readily than light does. • Observing that different materials absorb sound to different degrees. Solid, dense materials tend to transmit sound well. Soft or porous materials tend to make better soundproofing.
Anatomy/Physiology	• Noting that some children prefer to be near a radiator, while others prefer to be where it is cooler. • Noting that differences in physical characteristics are important in determining whether classroom furniture is comfortable.

ACTIVITIES IN CLASSROOM DESIGN UTILIZING SOCIAL SCIENCE

Process	
Observing/Describing/Classifying	• Organizing and classifying sets of ideas or information. • Observing and describing effects of noise level, distractions, or any physical disturbance in the classroom. • See also MATHEMATICS list: *Classifying/Categorizing.* • See also SCIENCE list: *Observing/Describing; Classifying.*
Identifying Problems, Variables	• Identifying different attitudes students have toward their classroom. • Identifying problems with the classroom. • See also SCIENCE list: *Identifying Variables.*
Manipulating, Controlling Variables/ Experimenting	• Devising tests to determine a person's ability to perform some task under varying conditions of light or background noise. • See also SCIENCE list: *Manipulating, Controlling Variables/Experimenting.*
Inferring/Predicting/Formulating, Testing Hypotheses	• Inferring from results of opinion surveys the types of decorations that should be obtained. • Choosing best method of distributing or organizing materials in the class based on speed and convenience. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Collecting, Recording Data/ Measuring	• Using voting procedure to determine preferences. • See also MATHEMATICS list: *Counting; Measuring.* • See also SCIENCE list: *Measuring/Collecting, Recording Data.*
Organizing, Processing Data	• Tallying votes for which type of table to build. • Tallying survey data or questionnaire data on opinion of classroom before and after changes have been made. • See also MATHEMATICS list: *Organizing Data.* • See also SCIENCE list: *Organizing, Processing Data.*

Analyzing, Interpreting Data	• Comparing qualitative information gathered from various sources. • Evaluating survey methodology. • See also MATHEMATICS list: *Comparing; Statistical Analysis; Opinion Surveys/Sampling Techniques; Graphing; Maximum and Minimum Values.* • See also SCIENCE list: *Analyzing, Interpreting Data.*
Communicating, Displaying Data	• Representing survey data, such as preferences about paint color, on graphs or charts. • Making charts or graphs that can be easily understood and will have the maximum impact on intended audience, e.g., the principal or school board. • See also MATHEMATICS list: *Graphing.* • See also SCIENCE list: *Communicating, Displaying Data.* • See also LANGUAGE ARTS list.
Generalizing/Applying Process to Daily Life	• Using the knowledge acquired from improving one aspect of the classroom to help solve other associated classroom problems, such as organization of supplies. • See also SCIENCE list: *Generalizing/Applying Process to New Problems.*

Attitudes/Values

Accepting Responsibility for Actions and Results	• Making sure that various tasks (e.g., measuring the room, finding out about fire regulations, duplicating survey forms) are done. • Scheduling hours and personnel at bake sales held to raise funds to buy construction materials. • Scheduling and giving presentations to persons in authority, such as the principal, to obtain approval for proposed changes in the classroom.
Developing Interest and Involvement in Human Affairs	• Promoting changes in classroom. • Attempting to improve conditions in other classrooms with the approval of the teacher.

Recognizing the Importance of Individual and Group Contributions to Society	• Recognizing that they can improve conditions in their classroom. • Recognizing that their improvement of the classroom will help the school, not only themselves. • Assessing the effects of group action on school regulations.
Developing Inquisitiveness, Self-Reliance, and Initiative	• Conducting group sessions with help from the teacher. • Dealing with various merchants to obtain supplies, e.g., construction materials. • Finding their own solutions to problems encountered in addition to the main problem of the challenge. • Choosing and developing the best way of presenting a plan to the principal, • Using the telephone to find out about regulations that might affect plans to rearrange the classroom.
Recognizing the Values of Cooperation, Group Work, and Division of Labor	• Finding that work on improving the classroom progresses more rapidly and smoothly when they work in groups. • Eliminating needless overlap in work. • Finding that work is more fun and proceeds more smoothly when people cooperate.
Understanding Modes of Inquiry Used in the Sciences, Appreciating Their Power and Precision	• Using scientific modes of inquiry to investigate and solve classroom problems. • Using data, graphs, and other supportive material to convince other people to accept a proposed solution. • Seeing that various classroom arrangements can be tried by using scale layouts. • See also MATHEMATICS and SCIENCE lists.
Respecting the Views, Thoughts, and Feelings of Others	• Considering all suggestions and assessing their merits. • Considering the opinions of others when proposing a change; conducting opinion surveys to determine colors to be used in the room.
Being Open to New Ideas and Information	• Considering alternative ways of doing various tasks. • Conducting library research on various aspects of a problem such as which materials make good soundproofing. • Asking other people for opinions, ideas, and information.

Learning the Importance and Influence of Values in Decision Making	• Realizing that cost effectiveness alone is not sufficient in considering a solution; effects on people must also be considered. • Realizing that preferences for various classroom arrangements reflect the values of each individual.

Areas of Study

Economics	• Using concepts and terms such as cost, profit, production cost, and retail price when building furniture or purchasing items for the classroom. • Performing cost analysis of materials. • Gaining experience with finance: sources, uses, and limitations of revenues for the purchase of equipment and materials for the classroom. • Assessing preferences, characteristics, etc., of users (i.e., classmates) through surveys or questionnaires. • Gaining experience in record keeping and comparative shopping for materials.
Geography/Physical Environment	• Investigating and changing the physical environment in the classroom.
Political Science/Government Systems	• Establishing rules for a new section of the classroom such as a reading center. • Investigating systems of administration and control. • Investigating regulations and policies affecting planned changes in the classroom. • Contacting and working with school authorities to obtain permission to carry out room improvements.
Recent Local History	• Investigating previous attempts to change the classroom.
Social Psychology/Individual and Group Behavior	• Recognizing and using different ways of approaching different groups. (Using a different approach for fellow students from that for a school board. Finding "best" ways to approach the principal or teacher about approval for suggested room improvements.) • Recognizing the need for leadership within small and large groups. Recognizing differing capacities of individuals for various roles within groups.

Social Psychology/Individual and Group Behavior (cont.)	• Analyzing the effects of a small group making decisions for a larger group.
Sociology/Social Systems	• Considering the integral, related nature of a community and its physical or recreational surroundings as a factor in the problem of making the classroom a better place. • Devising a system of working cooperatively in small and large groups. • Investigating problems and making changes that affect not only themselves, but society (other students in the school, people in community). • Working within established social systems to promote changes within the classroom. • Experiencing and understanding differences in social systems in different social groups (children, adults, women, men, homemakers). • Recognizing that there are many different social groups and that one person belongs to more than one social group.

ACTIVITIES IN CLASSROOM DESIGN UTILIZING LANGUAGE ARTS

Basic Skills

Reading: Literal Comprehension--Decoding Words, Sentences, and Paragraphs	• Decoding words, sentences, and paragraphs while reading books on light, heat, or sound; while reading catalogs of classroom furniture; while reading safety regulations, etc.
Reading: Critical Reading--Comprehending Meanings, Interpretation	• Obtaining factual information about light, heat, sound, classroom furniture, safety regulations, etc. • Understanding what is read about light, heat, sound, classroom furniture, regulations, etc. • Interpreting what is read, such as safety and fire regulations; books about light, heat, and sound; etc.
Oral Language: Speaking	• Offering ideas, suggestions, and criticisms during discussions in small group work and class discussions on problems and proposed solutions. • Reporting to class about data collection, scale-drawing activities, construction, etc. • Responding to criticisms of activities. • Preparing, practicing, and giving effective oral presentation to principal requesting funds to improve classroom or permission to make changes. • Using the telephone properly and effectively to obtain information or to invite a resource person to speak to the class. • Conducting opinion surveys about possible classroom improvements. • Using rules of grammar in speaking.
Oral Language: Listening	• Conducting interviews of classmates. • Following spoken directions. • Listening to group reports.
Oral Language: Memorizing	• Memorizing portions of oral presentations.
Written Language: Spelling	• Using correct spelling in writing.

Written Language: Grammar--Punctuation, Syntax, Usage	• Using rules of grammar in writing.
Written Language: Composition	• Writing to communicate effectively: • preparing written reports and letters using notes, data, graphs, charts, etc., communicating need for proposed classroom changes. • writing posters for classroom. • writing opinion surveys for classmates, devising questions to elicit desired information; judging whether a question is relevant and whether its meaning is clear. • preparing writeups of classroom rules to go with new tables or a new study area.
Study Skills: Outlining/Organizing	• Taking notes when consulting authorities or books about light, heat, sound, regulations, etc. • Developing opinion survey; ordering questions around central themes, such as preferences for paint color, classroom furniture, etc. • Planning presentations, data collection schemes, etc. • Organizing ideas, facts, data for inclusion in reports to other groups or presentation to principal.
Study Skills: Using References and Resources	• Using the library to research information on light, heat, sound, fire and safety regulations, etc. • Using dictionary and encyclopedia to locate information. • Finding an expert in interior lighting or soundproofing and inviting him or her to speak to the class and answer questions for them. • Using indexes and tables of contents of books to locate desired information. • Using "How To" Cards for information on making a scale drawing, using tools, etc.

Attitudes/Values

Appreciating the Value of Expressing Ideas Through Speaking and Writing	• Finding that classmates and teacher may approve of an idea if it is presented clearly. • Finding that the school will allocate money when presented with an adequate (written or oral) proposal.

Appreciating the Value of Written Resources	• Finding that certain desired information can be found in books on light, heat, and sound, or in catalogs of classroom furniture or classroom ideas.
Developing an Interest in Reading and Writing	• Willingly looking up information on light, heat, sound, etc. • Looking up further or more detailed information. • Showing desire to work on drafting letters or reports.
Making Judgments Concerning What is Read	• Deciding whether what is read is applicable to the particular problem. • Deciding how reliable the information obtained from reading is. • Deciding whether the written material is appropriate, whether it says what it is supposed to say, whether it may need improvement.
Appreciating the Value of Different Forms of Writing, Different Forms of Communication	• Finding that how information can be best conveyed is determined in part by the audience to whom it is directed. • Finding that certain data or information can be best conveyed by writing it down, preparing graphs or charts, etc. • Finding that certain data or information should be written down so that it can be referred to at a later time. • Finding that spoken instructions are sometimes better than written instructions, and vice versa.